Tense, Mood, Aspect, Diathesis

Their Logic and Typology

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Prospect

Wading through the vast literature on event structure, tense, mood, aspect, and diathesis,¹ the feeling one gets is that many of the key observations in the field have been not only made but repeated and reinvented many times over.²

Philosophers of action since Aristotle have, largely independently of linguists, been interested in the nature of action, events and causes (Bennett 1988). Logicians have sought for notations and principles to regiment and explain tense, aspect, modality and action (van Benthem 1982, 1984, 85, 86). A rich variety of action and process calculi have more recently arisen in computer science (Petri 1962, Pratt 1978, 1992, 1994b, Milner 1993, 1995).

In linguistics, typological surveys have given rise to wide-coverage theories aimed to describe and explain the distribution and development of tense, aspect, mood and diathesis systems across languages (Dahl 1985, 1998, Bybee et al 1994, Lapolla/Van Valin 1997). Literature theory has studied the use of tense and aspect to create narrative discourse (Benveniste 1966, Genette 1980 [1972], Fludernik 1993).

If anything is missing, it is ways to bring together different strands of research. The main goal of this work is to develop notation for that purpose. I would like it to show that many different approaches to tense, mood, aspect and diathesis or (TMAD) are not only compatible, but comparable in a common calculus. My ambition in this work is thus to make steps toward an axiomatisation of the wealth of data and generalisations accrued in the literature.

The only way to enable cumulative progress is to recognise earlier results and indicate where (if anywhere) new proposals differ from them. I try to mention previous work that I am aware of to further this aim, not to do fair justice to everyone. This is not a survey or a history of the field, but an attempt at a unification of its results. I am also not out to show anyone wrong, or claim some particular perspective (like mine) to TMAD superior to another. Like Aristotle, I would like to save the appearances (σώζειν τ̀ α υαινόμενα) of received views. I am happy to repeat what others have said earlier, in order to fit it the notation. I like to see TMAD theory converge (as I think it has been doing lately) instead of just going round in circles (which it has always been doing).

Much of the traditional literature on tense and aspect is informal, the more so the further one moves from words and phrases toward texts: there is a lot of imagery, examples and intuitive terms. Examples, impressions and imagery are very much to the point, as data or explananda. Impressions fall out as corollaries from the interaction of simple structures with complex contexts.

A striking observation that emerged during the work reported here is that intuitions, metaphors and images typically associated with particular TMAD forms can be quite as predictable and universal as the truth conditional constraints governing them. Connotations repeat themselves with awesome regularity from one language or form to another, where the calculus shows the denotation the same or similar enough. Many observations originally made about one language (English) reflect logical relations of compatibility and transpose surprisingly well to unrelated languages with similar constructions. This latter observation is confirmed by the survey in Johanson (1998).

But metaphors, when formalised, also qualify as explanantia (witness cognitive linguistics). I too shall try to operationalise central metaphors in the field, such as figure-ground (Wallace 1982), viewpoint (DeLancy 1982), and perspective, by giving them formal content. Giving courses of events a topology

² Aristotle had many of the key ideas, as will become apparent. Jespersen (1924) is an important traditional reference. The empirical typology of Johanson (1998) has remarkable reach and richness of detail. van Benthem (1977, 1982, 1985, 1986) is a logical typologist par excellence. Particular muses for this book were Leinonen (1982) and Santos (1996).
explicates the figure-ground metaphor. Logical notions of index (global variable) and abstraction (the abstraction operator) explicate viewpoint.

It is possible and advantageous to allow many interrelated perspectives at once, given well defined exchange relationships between them (van Benthem 1986, 1996). Many phenomena allow several alternative compatible analyses: the same entailments follow from different ways of splitting up the facts. This turns out to be one of the leading insights of the present approach. The network of ideas surrounding tense, mood, and aspect is densely populated, and there is a large number of interchangeable formalisations of many distinctions. My belief is that the sum total of significant, really different distinctions is much smaller. In compensation, they command a vast wealth of interrelations and mutual interpretations.

Instead of choosing between conceptualisations, it pays to determine the interrelationships in order to be able to shift perspective at will. If I am right, there is no absolute distinction between accidental and significant analogies in language. There are just smaller and bigger analogies.

Logical typology

The original program of the work was this: Develop a calculus of TMAD devices. Based on the calculus, define possible TMAD systems as combinations of options from the calculus. Use the conceptual grid to support TMAD typology and to allow logical inference as well as separation between forms. Example: Jespersen (1924:277) puts the past tenses of some well known languages into a table as follows:

<table>
<thead>
<tr>
<th></th>
<th>Greek</th>
<th>Latin</th>
<th>French</th>
<th>English</th>
<th>German</th>
</tr>
</thead>
<tbody>
<tr>
<td>real perfect</td>
<td>egraphe</td>
<td>scripsit</td>
<td>a écrit</td>
<td>has written</td>
<td>hat geschrieben</td>
</tr>
<tr>
<td>perfective</td>
<td>egrapse</td>
<td>scripsit</td>
<td>écrivit, a écrit</td>
<td>wrote</td>
<td>schrieb</td>
</tr>
<tr>
<td>habitual imperfect</td>
<td>egraphe</td>
<td>scribebat</td>
<td>écrivait</td>
<td>wrote</td>
<td>schrieb</td>
</tr>
<tr>
<td>descriptive imperfect</td>
<td>egraphe</td>
<td>scribebat</td>
<td>écrivait</td>
<td>was writing</td>
<td>schrieb</td>
</tr>
</tbody>
</table>

Table 1

My goal was to define a fine enough grid in which I can catch both the rows and the items in tables of this sort, so that I can actually prove that the items fill the cells in just the different ways they do.

This means that the calculus which provides the grid should optimally allow explicit formation rules, model theory, and deduction theory. I shall not provide all of that here. I do base my calculus on established formal systems whose syntax and axiomatics is well known.

Model theoretic semantics, in contrast to translation, corresponds to going to the dual of a language to reflect it. Different mathematics may become available, and gratifying new analogies may be gained in the conversion (such as the possible worlds interpretation of modality). In the last analysis, it really does not matter which way one looks at language. Pitting extensional (possible worlds) and intensional (event/situation) approaches as competitors turns a useful duality into an ideological choice (Barwise/Perry 1983, Hintikka 19??, Krifka 1998:199).

The formalisms I develop are the main thesis of the essay. I consider having accounted for those observations and impressions that are captured in the formalism. Descriptions of usage reported here are secondary to the relevant formalisations; they may be wrong as long as the formalisation is not. Impressions that cannot be derived as contextual entailments of the formalisations remain just impressions, and food for further thinking. I don’t mind platitudes, I am not after novelty. I mention facts if and when they may fit into a deductive system I try to formalise.

On the other hand, the particular shape of the formalism is not essential. It is enough to have any one formalism which unifies different approaches. There are others, interdefinable or in various respects superior to the one presented here. I sympathise with van Benthem’s catholic view on formalisms, relating logical varieties to one another through classical logic. There is linguistic interest in studying various logics which hide parts of classical logic from view, because natural language seems to do likewise.

My particular aim is to make simple things look as simple as I can make them, at the risk of losing detail. My growing conviction is that core TMAD is simple. There are relatively few genuinely different distinctions, once formal grain is sifted from impressionistic and terminological chaff (Johanson 1998). What complicates the analysis of tense and aspect is that it is intimately connected to other areas of grammar, in particular, diathesis, modality, reference and quantification, and discourse. In order to do justice to these connections, one cannot avoid forays into the interconnected areas.
This brings up another point of attitude. The fact that natural language and commonsense thinking is characteristically qualitative and vague does not mean that its explication could not be formal. The fact that people do not consciously use topological theorems does not prevent them from behaving as if they knew them. In general, I do not believe in a separation of natural language semantics and common sense thinking from formal semantics or exact thinking. There is no particular place where one ends and the other begins, no linguistic logic essentially different from mathematical logic.

I try to start from simple and undeniable distinctions such as: does an event have to go on or come to an end? Is this always so? Is it just generally the case? And so on. In compensation, I shall try to stick to my principles: apply distinctions literally, paying close attention just what event it is that aspect distinctions apply to in each case. I try to distinguish between entailment and implicature, hard-and-fast distinction and contextual inference. Unfashionably perhaps, I look for a logic in the imagery, associations, motivations, metaphors and prototypes. Though there are no sharp lines between analytic and synthetic, knowledge of language and knowledge of fact, grammar and lexicon, semantics and pragmatics, necessity and probability, there are clear cases of all of the distinctions.¹

**Categorical typology**

My current research program could perhaps be described as the study of the category of natural language TMAD systems: algebras of events $U$ through which different TMAD systems $S_1$, $S_2$ can be mapped into one another so that diagrams $S_1 \rightarrow S_2 = S_1 \rightarrow U \rightarrow S_2$ commute. The object of study is thus not a single system, but morphisms in the category of TMAD systems. This applies both to object natural language systems and metalanguage theories and models about them. Together with this perspective goes a category theoretic interpretation of “is”: one thing (algebraic structure) “is” another when they are the same up to an equivalence.

A related insight is that there is no unique set of privileged primitives for a TMA formalism. There are many interdefinable choices of primitives and sufficient sets of axioms relative to them. This much already follows from the underlying mathematics. Boolean algebra, regular algebra, relation algebra, topology, all can be based on many alternative choices of primitives. Before one runs different semantic approaches against one another in competition, one must put them on the same line to see which differences are substantial and what is only notational. Two systems are compatible until one says $p$ and the other not $p$ for the same $p$. Even so, good features of one system can often be incorporated in another, or a third system found which combines the advantages of two.

This is another point of attitude: there is no fixed semantics for natural language, rather, there is free play with category theoretic morphisms. There does not have to be any way to choose between perspectives for good. Natural language has no one intended model of events and time, it accommodates different world views (Benthem 1998:§8). Linguistic facts have many compatible explanations, corresponding to different partial theories sometimes subsumed by a more general one.² There need not be one correct semantic analysis of tense and aspect. As long as all observations agree, many theories may be correct at the same time (Quine 1960). (Compare also van Benthem's program for semantics in 1986:§10).

The same may be true of grammar as a whole. Conceivably, there is no one perspective, logical form, model class, or syntactic theory which does justice to the grammar of a given language, or even one construction. We may have to switch perspective in the middle of analysis. This is a logical analogue of etymology, where no one schematic meaning or prototype may cover the entire spectrum of uses of a word. The grammarians’ “is” may have to be equally abstract than the mathematician’s, that is: operate on the level of morphisms, or analogies, as they are named in grammar.

I think grammatical constructions in natural language are multiply mapped rather like its semantics, they allow alternative partial analogies which are used to extend the system in different directions as it evolves. A Wittgensteinian toolbox view, or more fashionably, a radical constructionist view of language, instead of a quest for the underlying structure (Croft 2001). There need not be any one underlying structure of language or ideal notation for linguistics, no more than there is one for mathematics.

It may also be possible to explain the same phenomenon by a grammatical, semantic, or discourse rule, and predict the other rules from the choice. If there is no way to choose, why choose. Any one, or all

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¹A vague concept can strictly entail another vague concept. If it is true that swans are white, it is not true that swans are black (Altham 1971:45).

²Two theories are only inconsistent if their conjunction entails a contradiction.
three can be right: language is redundant. Redundancy is a locus for neutralization, which change may tell apart.

Language typology can be approached top down or bottom up. The (currently perhaps more popular) top down, semasiological or functional typology starts from some function like passive, perfect, or future and studies how it is manifested across languages. The shared function is used to explain variation and unity of structure. Bottom up, onomasiological or structural typology starts from some construction type like word order or case system and studies its variations. The shared structure is used to explain variation and unity of function. I work mainly bottom up. Both perspectives are useful, and dually complement one another.

It used to be customary in logic grammar works of Montague vintage to present a fragment of a natural language complete with syntax and semantics, just as a proof of concept. The exercise has lost some of its initial interest given the degree of freedom in the task (van Benthem 1986:200).

I won’t provide separate rules for translating natural language fragments into the calculus. I hold on to a hope that the calculus itself will become flexible enough to allow surface true representation of natural languages. This hope is a radical form of Montague’s project of English as a formal language. Only I am going to venture past English to languages of many types. Compared to Montague’s semantics, a difference is that I do not hang on to categorial type theory, but go to dual or adjoint types when I want to.

**Disposition**

The *opus magnum* is divided into three parts. The first part lays out the calculus of events (and objects). The second part applies it to a selection of individual languages. The third part pulls together results from Parts I-II toward a logical (and developmental) typology of tense, mood, aspect, and diathesis.

The order of the four accidents of the verb in the title corresponds to their logical scope in the Creole prototype. The logical order of presentation in the book reflects my progress in digging into event types.

The first part is divided into chapters on the formalism, aspect, tense, time adverbials, time within the sentence and discourse, modality, diathesis, and object types.

The second part consists of case studies of the TMAD systems of a range of languages, including English, Portuguese, French, German, Russian, Classical Greek, Bulgarian, Finnish, Chinese, and casts cursory glimpses at a number of others, including Creole languages, Hungarian, Icelandic, Inuktitut, Irish, Japanese, Kikuyu, Lezgian, mainland Scandinavian, and Turkish.

The third part pulls together consequences of the theory and the empirical studies for the typology of natural languages. The part is divided into a chapter each on traditional structural ideas, more fashionable evolutionary or developmental typology, and logical studies.

A work which traces the interconnections of a wide range of facts really ought to be shaped as a hypertext. In print, anticipation and repetition is unavoidable, as the same facts take part in generalisations in different directions.

The work will appear abstract at start, and its fabric loose from nearby, but the plot thickens. It can be faulted for being too long, or trying to fit everything in. The only defense is that it is just what this work is about: it is an attempt to fit a lot of things together.

**Part I. Theory**

The study of concepts related to TMAD will profit from elementary use of the many branches of mathematics they involve. Some relevant distinctions such as open/closed, point/region (dis)connected, (dis)continuous are topological. Some are metric, like short/long, (un)bouded. Some are order concepts, like before/after. Some are algebraic, like product, sum, iteration and complement. I shall be using something from all of them. I shall try to use terms in their usual mathematical senses, as defined e.g. in Kelley (1955), Chang and Keisler (1973), Salomaa (1973), and Halmos (1956, 1974).

Lattice theory provides the concepts of partial order, lower and upper bounds, limits, completeness and continuity. It builds on the theory of order relations, which defines linear, dense, continuous, partial, backwards linear, or weak orders. At the concrete end, there is the theory of the real time line. Relation algebra studies properties and operations of relations.

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I try to stick to received topological terminology of connected spaces and continuous functions.
Topology is qualitative geometry. It explicated the concepts of discrete and continuous, separate and connected, inside and outside, open and closed, neighborhood, adjacency, and boundary. Ordered topological spaces define the concept of convexity. Metric (uniform) topological spaces produce the concepts of duration and distance (long and short, near and far).

Ordered topological spaces define the concept of convexity. Metric (uniform) topological spaces produce the concepts of duration and distance (long and short, near and far).

Projective and affine geometry have marginal aspectual relevance too. A projection, generally, is a map from a space to a quotient space with simpler structure (Kelley 1957, Mac Lane/Birkhoff 1967). Projective geometry in particular defines perspective, which is an important metaphor in aspect theory. In a projective space parallel lines meet at a point or line at infinity: a point of view or horizon. Viewed up close or from within, a region fills the horizon and seems unbounded, viewed from outside at a distance, it seems bounded and contracts to a point (Kamp 1981b:51). Changes of scale in turn are linear (affine) transformations.

The theory of regular languages belongs to formal language theory dealing with semigroups and monoids. Graph theory combines theories of relations, orders, group theory and topology. Its key concepts include graphs, trees, cyclicity, and connectedness.

Significant parts of these different mathematics are closely related, in fact identical in the sense of category theory. Thus at the abstract end comes category theory, the theory of invariants of algebraic systems in terms of functors and morphisms, which allows a birds-eye view on notions such as resolution (Link 1998:255) or duality (van Bentham 1982:§I.2.3).

**Duality**

A key concept turns out to be the category theoretic notion of duality (MacLane/Birkhoff 1967:32ff, Bentham 1986, Pratt 1997, Barr/Wells 2002:5). In terms of category theory, the dual of a diagram is obtained by reversing arrows. Duality is relative to a diagram, so a concept can have more than one dual relative to different diagrams. For instance, meet is the Boolean dual of join and the ring dual of +. Once one puts on the right glasses, there are dualities all over. Boolean dualities actually form Aristotelian squares or Klein four groups between a concept, its complement, dual and antidual (Halmos 1974:8, Löbner 1986,1990:§4). Those that have been collected here will come up in one form or another in the body of the work.

Or is dual to and. Some is dual to all. Also is dual to only. Part is dual to whole. Big and small are dual. If is dual to only if. Possible and necessary are dual. Negation, equivalence, one and the are self-dual (Löbner 1990:76). Boolean dual and complement fall together in 2.

Boolean algebras and discrete topological spaces are dual (Stone). Ideals and filters are dual. A set is dual to its power set. The converse of a linear order is its dual. Minimum and maximum are dual. Partial and total functions are dual. Discrete and continuous are dual. Product and sum, quotient and difference are dual.

Category theory objects and arrows are dual. Morphisms and their inverses are dual. Morphisms and composition are dual. Initial and final algebras are dual (Baillie 1989). Induction and coinduction are dual (Rutten 1995). Properties and relations, Boolean and relation algebras are dual.

Geometry generates many dualities. Long and short, straight and round are dual pairs. Inside and outside, point and line, line and plane, line and circle (angle/arc) are dually related. Edges and vertices, paths and boundaries are dual. Vectors and matrices are dual. Integral and differential are dual.

Inanimate nature exhibits dualities. Time and space can be dually related. Potential and flow are dual. Open and closed systems are dual. Concatenation and superposition are dual. Particles and waves are dual. Information and entropy are dual.

Animate nature likewise. Organism and environment are dual. Freedom and determinism are dual. Agency and accident are dual. Strategies and utilities are dual. Knowledge and power are dual. Brain and brawn are dual.

Language abounds with dualities. Types and tokens are dual. Objects and their properties are dual. Languages and models are dual. Form and content, structure (category) and function are dual. Morphology and syntax, syntax and semantics are dual.

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6The Stone representation theorem (Halmos 1974) proves Boolean algebras isomorphic to discrete topological spaces. A consequence is that Boolean algebras can be represented by point sets (and vice versa). Point set topology needs three individual variables (e.g. continuity, between), or dually, two set variables (e.g. connectedness, closure).

7This is the duality of the two Kirchhoff laws for flow through a crossing and potential round a circuit.
Duality turns up in tense and aspect. Events and states are dual (Pratt 1992). Events and objects are dual. Propositions and times are dual. Past and future are dual. Open and closed events are dual. Imperfective and perfective are dual. Loose (location) and tight (duration) adverbials are dual. Before and until are dual. Between and from-to are dual. In and for are dual. Duration and frequency are dual. Tense (non locally testable, dense event types, live properties) and aspect (locally testable, closed event types, safety properties) are dual.

Mood has its dualities. Possible worlds and situations are dual. Possible worlds frames and modal algebras are dual. Cause and let are dual. Able and happen are dual. Habits and dispositions are dual. Subjunctive and optative are dual. Liveness and safety are dual.

So does diathesis. Cartesian product and identity, or passive and reflexive are dually related. Active and passive are order duals. Reflexivity and iteration turn out to be dual as well.

In grammar, word order and morphology are dual. External and internal cases are dual. Count and mass, singular and plural are dualities.

On the side of theory, generative and constraint grammar, generative phonology and optimality theory can be considered dual respectively. Parsing and generation, left-right, top down-bottom up, deterministic-nondeterministic, depth first-width first, are all dualities. Languages and automata are dual. Variables and combinators are dual. Imperative (procedural) and declarative programming are dual. Control flow and data flow are dual. Sorting and permutation are dual. 8

In discourse, foreground and background are dual. Settings and episodes, frames and scripts are dual. Metaphor and metonymy are dual.


Duality saves work, as one only has to solve one half of a problem. Often a complex problem becomes simple by going over to the dual (well, complex and simple are dual concepts).

**Conceptual tools**

Table 2 represents the events on a Monday morning. Time runs in columns, simultaneous events in rows. Each cell represents a (simple or complex) event token. The white cells are (relatively) simple event tokens, the shaded ones are (more) complex event tokens involving simpler events on the previous rows.

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8There are dualities between the Chomsky language hierarchy and the corresponding automata, e.g. between regular, context free, and indexed languages and iteration, nesting, and queuing (second order pushdown automata).
A starting point of my way of modeling events is that events of a type are not unique. An event of a given type can contain, be contained in, precede or follow other events of the very same type (Declerck 1997:64,104). This should be particularly clear with open event types. For instance, the complex event of waking up can be stretched to cover anywhere from the whole course of events to an arbitrary narrow neighborhood of the instantaneous change of state (if any) from sleep to vigilance. Although there are two cells labeled *wake up* in the graph they count as parts of the same event of waking up whose boundaries are not fixed. A description of an event in process like *I was waking up* can denote a complex course of events including the alarm clock going off, sitting up in the bed and yawning, and so on. When pressed, we may be able to zero in on the actual moment of awakening, but usually we don’t, and there doesn’t even need to be one. Although we know more or less when the event happened we are not exact about when it started and where it ended and what details were involved in it. Events are not individuated up to identity as concerns their boundaries or internal detail, although we can count how many of them there are within a given course of events. Compare counting waves. At any given scale or granularity, we can count how many waves there are without being able to say exactly where one ends and the next one begins. For a finer resolution, we can count more waves (Bennett 1988:§34,§49).
A consequence is that all events, closed events as much as open ones, are vague about their boundaries. Closed events are vague too because they include their boundaries, and the boundaries are states. Looking back, this was one of the emancipating ideas in this approach. We tend to think of events as regions and their boundaries as points. But we can dually think of the bordering regions as the boundaries of a point. This may be part of what writers of aspect have in mind when they talk of the perfective and imperfective perspectives on an event as viewing an event from the inside as extended, or from the outside, contracted to a point (Lyons 1977:708-710, Smith 1991:104). The difficulty of turning the metaphor into formal sense comes from thinking too concretely in terms of some fixed model of time. The point-region distinction is generalised by the open-closed distinction in general topology, which our models are an instance of. I return to this in the section on topology.

**Resolution**

A good model of events should embody the ideas of *resolution*, i.e. *granularity* and *scale* of events. Granularity concerns possibly discontinuous projections that smooth or coarsen a course of events (Hobbs 1985, Euzenat 1993, Link 1998). Scale concerns continuous affine transformations changing unit and origin of measurement (Krantz 1971). Scale splits a course of events into sequences of subevents with varying scale, which corresponds to continuous stretching or contracting of the course of time. Scale helps understanding continuity and relating it to discrete change. It is sound mathematical practice to capture continuous change as the limit of series of discrete changes of ever finer scale.

Granularity sums up, selects significant and leaves out insignificant or eventless bits, thus redefining the contiguity of events at each level of resolution. It is entirely true to say, on one level of resolution, that I got up immediately after I woke up, although it is also true that I did sit up and slam on the alarm clock in between, if we look at the events more closely. This is part and parcel of the qualitative, *generic* nature of natural language. There is a dependence between distance and scale due to perspective. Given constant resolution (number of noticeable differences), one can discern finer detail close by, while the same number of distinctions will produce coarser divisions far away. Perspective contracts distant objects to a point and expands nearby ones.

This is consistent with the recurrent idea of constructing pointlike events as atoms in a Boolean algebra of events, while an event is extended if it has common parts with other events (Wiener 1914, Kamp 1979,1981b:48ff, Löhner 1988:169). Kamp’s discourse representation corresponds to a level of resolution at which events appear as points, while at a finer scale of physical time they turn out to have internal parts. Thus what counts as a point depends on the topology one is working with, which depends on granularity. So it is possible for an event type (say, a generic state like be reliable or smoke) be true pointwise at a given resolution, while not true and false at each and every point at a finer resolution. That *He is reliable* and *he smokes* are true does not imply that *He is being reliable now or he is smoking now are*. There are branches of mathematics that deal with scaling, smoothing, and simplification of complex quantitative phenomena so as to turn a detailed image or quantified proposition into a coarser picture or a qualitative, categorical assertion. So far, applications to linguistics have been of marginal relevance (Thom 1970, Zadeh 1978, Yang 2001). Granularity in space is studied in Narashimhan/Cablitz (2002).

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9McCoard 1978:84 makes similar points about the vagueness of *He grew old*, *Man descended from the apes*, and *I overslept this morning*. Dowty (1977:54) initial definition of *become* is vague in the same way, but he finds the vagueness counterintuitive and considers ways to rule it out. Galton (1984:34) makes the point that although a change can only be located within an interval, it is still an instantaneous change because there is no lower limit to the length of intervals which contain it.

10Cf. principle P2 of Eberle and Kasper 1994: The PS presents an event as punctual, while the Imp presents the state or condition it reports as extended.

11These ideas seem compatible with Lindstedt’s (1985:102) notion of *occasion*: time consists of moments, history consists of occasions, where an occasion is a slot for an event in a course of events. Cf. *scale* in cognitive grammar (Langacker 1987:118) or the discussion of *next* in Cooper (1986:22-23). Cf. also *region* in Klein (1994).

12Euclid’s definition of point as what has no parts is perfectly to the point, relative to point of view.
Algebra


Imagine a set A of (atomic) event (token)s a partially ordered by concatenation. From it construct a set S of longer or shorter courses (sequences) of events from A. In formal language terms, A is a vocabulary and S is a language, i.e. a subset of A+. A complex event (token) x is set of simple courses of events, i.e. a sublanguage of S. Thus for instance a complex event token of type build a house can include all sorts of subevents like carrying stuff, casting concrete, nailing, etc. A complex state like be helpful can include helpful acts. The set of such complex event (token)s R is a subset of the power set of S. Complex event tokens need not be connected. A complex event token d is a subevent of e if d ⊆ e. This way of defining subevents makes subevent structure like a Boolean algebra, i.e. there is no unique fixed split of an event into subevents.

Event tokens can be split into smaller events on orthogonal dimensions (Link 1997). An event may be a temporal part of another event (for instance, coughing consists of a series of coughs), or it may be a spatial or logical part of another event (carrying two suitcases may involve carrying one in each hand; kissing by definition involves touching; Ar. Phys.VI.4) The relations may hold at the same time. Consider for instance Herweg’s (1991) example tune a violin consisting of interleaved subevents of iteratively tuning strings on the violin in turn. Times are sets of simultaneous events. Events in a complex event do not have to be simultaneous in general, but events at a given time are. Neither times nor events need be connected (e.g. sleep at nights).

An event type in turn corresponds (in this set theoretical first approximation) to a set of complex events. The set of event types E is a subset of the power set of R, corresponding to families of languages in formal language terms. A time t is also an event type, i.e. a set of complex events (possibly in different situations or alternative futures). Thus the set of times T is another subset of the power set of R. An event type is on the same level of complexity as a time (i.e. a set of sets of simple courses of events), they only cut the set of simple event tokens differently. The set of times T must be congruent with concatenation so that events x,y et only if x≤y entails y≤x. Times are equivalence classes of the indifference relation induced by concatenation (van Benthem 1982:118-9)\(^\text{15}\)

This formulation is impartial about possible worlds: simultaneous courses of events may happen at the same location, at different locations, or in different alternative possible worlds.

Tha above construction will not be developed in the sequel. It only serves as a guide to intuitions on the way to an algebraic treatment, where event types are individuals on their own right (Keenan and Faltz 1985:52, Link 1998:252).

My event calculus will be built on a number of well known and closely related algebras, Boolean algebra, regular algebra for events, closely related to relation algebra for objects, and an algebra of transducers to describe relations between objects and events. These algebras can be related to one another using common concepts from universal algebra or category theory.

All of the algebras build on the basic category theoretic constructions of product, projection, adjoint, identity, terminal element, and their duals.

The algebras are related as product algebras of one another. Regular algebra is a monoid of Boolean algebras, or equivalently, a Boolean algebra of monoids. Relation algebra extends it by having converses. Transduction algebra in turn is a relation algebra of regular algebras.

I distinguish several sorts of variables: nonempty free (existentially bound) event or object type variables d,e,f,g, untyped possibly null event or object token variables x,y,z, either free or bound, time variables t,u,v, sorted event type variables a,b,c,d,m,p,q,r,s with aspect restrictions on their values, and contextually bound (indexical and anaphoric) token variables I, here, now and then. Despite the traditional name, now and then here do not (only) range over times but over event types; i.e. they can exhibit aspect.

I follow a common convention according to which identical variable tokens corefer within a formula while different variable tokens do not (so different tokens can denote different events). Given I do not make a sortal distinction between types and tokens, the difference between type and token variables is not in their range but how they are instantiated. Type variables are call by name, evaluated outside in, token variables are call by value, or inside out. For instance, event type (eat x)+ describes rumination,

---

\(^{15}\)Further conditions can be imposed on times, e.g. that T is closed under unions, allowing every other day to denote times (van Benthem 1982, Vlach 1993:245fn).
or eating the same thing again, eat x . eat x, while eating twice eat+ is the same as (eat _) and instantiates to eat _ . eat _ or eat x . eat y. (Comon et al. 2002:66)

< is an anonymous free string variable over times/event types. It is a notational variant of the identity or top element 1 of the regular event algebra. _ is an anonymous variable over concatenation atoms, so _ equals 1 and < equals _. These variables are never shared. The interpretation of _ as an atomic variable only makes sense on discrete time. In dense time, let _ denote the event type of extended events in 1^*Φ^*.

Genetically, the starting point of event calculus was the language algebra of extended regular expressions. (McNaughton/Yamada 1960), or a combination of Boolean algebra and regular expressions (Aho/Ullman 1972, Rozenberg/Salomaa 1997). It is related to relation algebra (Jonsson/Tarski 1951, Ng/Tarski 1977), which in turn is related to dynamic algebra/logic and two-dimensional logic (Pratt 1978,1992,1994, van Benthem 1996), thus indirectly even to such less obvious cousins as Petri nets (Petri 1962, Winskel 1986) and linear logic (Girard 1987). For a family tree, see Pratt (1992c).

**Boolean algebra**

Boolean algebra (Halmos 1974) defines join (union) \( \bigcup \), meet (intersection) \( \bigcap \), complement \( \neg \), sum (symmetric difference) \( + \) and relative complement (difference) \( \setminus \), material conditional and equivalence \( \leftrightarrow \).

I occasionally leave out \( \bigcap \) between event types, i.e. use them as homonymous intersecting modifiers (equivalently, one-place prefix or postfix operators under composition, cf. relation algebra). A particular natural language, as an instance of the calculus, will include event type constants for individual verbs.

The *Boolean sum* of events \( a+b \) is the same thing as symmetric difference \( a \cup_b a \cap_b \), exclusive disjunction \( a \oplus_b \neg \neg a \oplus_b \neg \neg b \). It is commutative and associative, so \( a+b = b+a \) and \( (a+b)+c = (a+b)+c = a+b+c \). Join is defined in terms of sum as \( a \cup_b = a+b(1+a) = a+b(\neg a) = a+b+ab \) (Boole 1858:56)\( ^{14} \)

Boolean algebra is also an *idempotent ring* relative to meet and sum, obeying the arithmetic of 0 and 1 modulo 2 (Halmos 1974), in which \( a^2 = aa = \varnothing \rightarrow a = a \). In this arithmetic, every element is self inverse: \( a+a = \varnothing \) so there is no sign: \( a = \neg a \), and \( \varnothing \leq a \leq 1 \).

Specifically, \( 1a = 1+a \). This is the only sum time and difference coincide. In general \( a+b = a\cup b + b\cap a \), for instance \( a\varnothing = a \) and \( \varnothing a = \varnothing \) so \( a+a = a \). The law of cancellation does not hold for meet, so \( a\cap b = a\cap c \) does not entail \( b = c \) even for \( a > \varnothing \) (Boole 1858:14). It fails for join as well, but holds for sum and equivalence, so \( a+b = a+c \) and \( a\leftrightarrow b = a\leftrightarrow c \) entail \( b=c \).

A Boolean algebra is also an additive Abelian (commutative) *nilpotent group* of order 2 where every element is nilpotent: \( 2a = a+a = \varnothing \cap a = \varnothing \) (Halmos 1974:3)

The initial object of the category is the two-element ring \( 2 \) of integers modulo 2 where \( 2 = 0 \) (the arithmetic of even and odd). The only smaller object is the one-element group whose cycle length is 0, the *trivial Boolean algebra* where \( \varnothing = 1 \) (Chang/Keisler 1971:291).

Boolean sum \( a+b \) is at once the dual and the complement of equivalence. It has dual disjunctive and conjunctive normal forms \( a\cup b \cup b\cap a \) and \( a\cup b \cap \neg a\cup \neg b \). Equivalence has the dual forms \( a\cap b \cup \neg a\cap \neg b \) and \( a\cap b \cap \neg a\cup \neg b \). Note the following equivalences.

\[
\begin{align*}
    a\leftrightarrow b &= \neg a\leftrightarrow \neg b = \neg(a+b) = \neg a \leftrightarrow \neg b \\
    a\cup b &= \neg a\cup \neg b = \neg(a\cap \neg b) = \neg a \cup \neg b = a\leftrightarrow \neg b
\end{align*}
\]

A Boolean algebra is also a *complemented distributive lattice* ordered by a partial order of inclusion \( \subseteq \). Lattice theory defines monotonicity \( a \leq b \rightarrow f(a) \leq f(b) \), distributivity \( f(a \cup b) = f(a \cup f(b) \cap f(e)) \). These notions are related through the lattice equivalence of \( a\cup b = a \) (absorption) and \( \subseteq b \). A tree is a one-way linear semilattice and linear order is a two-way linear lattice.

Boolean inclusion as an event type always denotes an element of the Boolean algebra \( 2 \). Material implication \( a\rightarrow b \) (residual, Pratt 1991, Kozen 1992, 1994, van Benthem 1991,1996:69) is a dual to

\[^{14}\text{There is equivocation in the use of } + \text{ in subsequent literature between Boolean join and sum. Boole (1858:58-60) holds to sum but makes the distinction explicitly each time.}\]
difference (quotient) \( b/a \). Inclusion \( \subseteq \), can be defined in terms of identity and join as \( a \cup b = b \), in terms of identity and meet as \( a \cap b = a \), or in terms of residual or difference as \( b/a = \emptyset \) or \( a \rightarrow b = 1 \).

It is also possible to let \( a \subseteq b \) denote the Boolean interval of elements between and including \( a \) and \( b \). Any nonempty Boolean interval is also a Boolean algebra. In particular, \( \emptyset \subseteq a \) equals \( a \) and \( a = a \) is the two-element algebra \( 2 \) of \( \emptyset \) and \( a \). On this interpretation, \( a \subseteq b \) is true just when it is not \( \emptyset \). This is a dual of the usual definition of inclusion (Hughes/Cresswell 1968:318fn317). It compares to my treatment of \( \leq \) in regular algebra.

A complete Boolean algebra adds infinitary versions of join and meet. Complete join \( \bigcup e \) and complete meet \( \bigcap e \) denote the top (lowest upper bound) and and bottom (greatest lower bound) of \( e \) with respect to inclusion. These are second order operators. Kleene star \( e^* \) can be explicitly defined as the fixpoint \( \bigcap x : x = xe \).

(Complete) sum \( \sum e \) is an analogous generalisation of disjoint join. \( \sum e \subseteq \bigcup e \). The (complete) sum \( \sum e \) is an (n infinitary) join of pairwise disjoint elements (relative atoms). When the events in the sum belong to the same event type \( e \), we may define multiples of the event type by setting \( 0e = 0 = 0^*, (n+1)e = e(n+1) = ne+e \). Plural definite the men denotes \( \sum \text{man} \). Note that the regular event type \( e^* \) is included in the Boolean event type \( ne \). For instance, \( e.e \) is a subtype of \( e+e \).

\( \sum e = \bigcup e \) when \( e \) is a partition, i.e. a set of relative atoms which forms a basis for a quotient algebra of \( e \), i.e. a resolution of \( e \). Note the connection to event resolution above.

Perspectives on Boolean operators are diagrammed in the following. Boolean product or meet is symbolised by concatenation.

The product algebra \( axb \) of Boolean algebras with operators defined pointwise is a Boolean algebra. The atoms of the product are the disjoint joins of concatenations of the atoms of the factors (Halmos 1971§26). There is an isomorphism between sum and direct product of Boolean algebras. All Boolean algebras are direct powers of \( 2 \). A regular algebra in turn is the concatenation closure of a Boolean algebra, or equivalently, a Boolean sum of (morphisms on finite) monoids.
Atoms

An atom*b in a Boolean algebra is an element without proper parts, i.e. whose only parts are ø and b itself: Note that ø is an atom, 1 is one only in 2. Atoms are terminal elements in a category (Bart/Wells 2002:4).

An element or an algebra is atomic if it is a sum of atoms, and atomless if it contains no atoms. An atomless algebra is dense: every element contains another, i.e. b ⊆ a for some b for all a. This means every nonempty element a is divisible into two, b and ab. In an atomic algebra every element is a sum of atoms. Atomic and atomless are contraries.

A Boolean algebra b can be split into two at any element a so that the product (b∩a) x (bla) of the quotient algebras is isomorphic to the original algebra b. (The product is dual to the Boolean sum.) A Boolean algebra can be split into an atomic and and atomless part in this way (Chang/Keisler 1971:295).

Every element a of a Boolean algebra b defines a smaller quotient algebra a∩b whose unit is that element. The sum algebra of Boolean algebras a+b with operators defined pointwise is a Boolean algebra. Then the atoms of the sum are sums of atoms of the terms.

The product algebra a.b of Boolean algebras with operators defined pointwise is a Boolean algebra. The atoms of the product are the disjoint joins of concatenations of the atoms of the factors (Halmos 1971§26). A regular algebra is the concatenation closure of a Boolean algebra, or equivalently, a Boolean sum of monoids.

Given a Boolean algebra with elements a and b, call a an atom relative to b if a∩b is an atom in the quotient algebra by b. Then a∩b is either a or ø. This is a symmetric relation.

Atomic inclusion a ≤ b can be defined in Booleans to mean ‘a ⊆ b and a is an atom’. It is the Boolean counterpart of the set theoretic notion of membership. Atoms allow defining immediate inclusion x ≤ y as the relation ‘x+a = y and a is an atom’. In an atomic algebra, proper inclusion ≤ is the transitive closure ≤ of immediate inclusion and inclusion ≤ is its reflexive transitive closure ≤. Meet, inclusion and identity fall together among atoms. So do join and sum. If a is an atom,

(a ≤ b) = (a∩b>ø)

If a and b are atoms,

(a=b) = (a≤b) = (a∩b>ø)

The Boolean dual of meet is join, the ring dual of meet is sum. Identity and sum are complementary in 2. It is the largest all-atom Boolean algebra. The dual of an atom is the complement of an atom, or a coatom. Any element of an atomic Boolean algebra is a meet of co-atoms. The meet of all co-atoms is ø.

A Boolean algebra is dual to a discrete topological space (a field of subsets). A topological base of a Boolean algebra A is a subset B that every element of A is join of a subset of B. The atoms of an atomic A form a base. It is also a factorisation in that every element is a unique sum of atoms. A cobase of is a subset C such that every element of A is a meet of elements of C. It is a factorisation if the meet is unique. The set of coatoms is a factorisation. A cobase C is free (independent) if every proper subset of C has nonempty meet.

A Boolean base (set of generators) for a Boolean algebra A is a set B of elements so that A is the closure of B under Booleans. Topological base and cobase are Boolean bases.

A Boolean valuation on a set F of elements e of a Boolean algebra A is a function f from F to A whose value for each e is e itself or its complement. The set of such valuations is of type 2^2^F. A Boolean base F is free if every valuation f on F is consistent (has a nonempty meet).

A Boolean algebra is free if it has a free base B. This means that any mapping from B to a Boolean algebra can be extended to a Boolean morphism. Boolean algebras 2, 4, 16, and 256 are free (they are feely generated by zero one, two, and three elements of atomic features, respectively). The three-atom, eight-element Boolean algebra 8 is not free.

Any Boolean algebra is a product of free Boolean algebras, so it has a base which is a sum of free bases. The size of the smallest complete featureisation of a Boolean algebra is log_2 the size of the

15I try to talk about atomic algebras and atomary elements, with partial success.
algebra. For instance, the Boolean algebra generated by two features (independent elements) \( a, b \) is the four-atom sixteen-element \( BA \). Its atoms are the fourfield \( a \wedge b, a \wedge \neg b, b \wedge a, \neg a \wedge \neg b \).

The size of a Boolean algebra is always a power of two, and that of a free Boolean algebra \( 2^2^n \) for \( n \) the size of the carrier. There are 2 Boolean in 2, four in 4 of which 2 are the same as in 2, sixteen in 16 of which 6 the same as in 4. This leaves 10 live binary ones in 16, of which 8 have been given short symbols. The two left over are each alone sufficient for defining the lot, Sheffer stroke \( a \uparrow b = (a \wedge \neg b) \) and its dual \( a \downarrow b = (a \wedge \neg b) \). More on Boolean algebra in the Appendix.

**Regular algebra**

The language of regular events consists of concatenation symbolised by juxtaposition between one-letter variables and by a dot between longer terms, Boolean: join (alias alternation \( \uparrow \) \() \cup \), optionality \( ? \), Kleene star \( * \), iteration \( ^+ \) (at least once), the empty event type \( \emptyset \). Relations include identity \( = \) and inclusion \( \subseteq \), which can be defined in terms of identity and join as \( a \cup b = b \).

The regular operator \( * \) called iteration is concatenation closure, i.e. implies adjacency (contiguity) just as much as concatenation does. There is no bias for or against discreteness involved although the term may suggest it. Discrete repetition or series is the special case of iteration of closed events.\(^{16} \)

Empty event type \( \emptyset \) is distinct from the null event type \( \emptyset^+ \). The former denotes nothing (is contradictory), the latter denotes the null event (concatenation identity, a virtual event that happens all the time yet takes no time).\(^{17} \) \( \emptyset \) is the Boolean unit event type \( 1 \). Optionality \( e? \) can be defined in terms of join and the null event type as \( e \cup \emptyset^+ \). The usual Kleene star is defined by \( e^* = e^+ \cup \emptyset^+ \). Finite powers \( e^n \) can be defined in the obvious usual way. For instance, \( \emptyset^* = \emptyset \). Notation \( e^{(n,m)} \) denotes the join of powers from \( n \) (exclusive) to \( m \) (inclusive). For instance, \( e^n = e^{(0,n)} \) and \( e^* = e^{(0,\infty)} \).

More precisely: regular algebra, or Kleene algebra (Conway 1971, Kozen 1991,1994), or the algebra of monoids (Pin 1991), consists of a noncommutative but associative operation of concatenation with zero \( 0 \) and unity \( 1 \). It is denoted by the language of extended regular expressions.

A *monoid* is a semigroup with unit, i.e. an algebra with an associative and noncommutative product called (concatenation) product \( a \cdot b \) and a two-way concatenation identity \( \emptyset^* \). For instance, a category is a monoid of arrows. Left and right projections \( a, b \) of concatenation \( a \cdot b \) are denoted by \( a^\uparrow \) \( b^\downarrow \) and \( a^\downarrow \) \( b^\uparrow \). Quotients \( a/b \) are adjoint to concatenation so \( a \cdot (a/b) = ab = (a/b) \cdot b \).

Concatenation is a free (cartesian) product satisfying cancellation \( a \cdot b = \emptyset \iff a = \emptyset \) or \( b = \emptyset \) as long as the domain of event tokens is a free monoid. (Cf. relativisation in van Benthem 1996:66)

A Kleene algebra or the algebra of basic regular expressions adds empty element \( \emptyset \) and complete join \( \cup \) which allows defining alternation \( a \uparrow b \) and concatenation closure (Kleene star) \( a^* \) (Kozen 19??, Desharnais 19??). Regular algebra or the algebra of *extended* regular expressions adds the rest of the Boolean, including meet \( \wedge \) and, complement \( \neg \) and the unit element of regular algebra \( 1^* \) dual to \( \emptyset \).

The *carrier* of a regular algebra is the sum of its atoms, singled out when need arises by \( 1 \) (also known as *alphabet* in formal language theory). The type of nonnull events \(- \) is \( 1^* \). Note that \( \emptyset^* = 1^* \).

Boolean algebra is not an extensivity category for multiplication does not satisfy cancellation, i.e. \( a \wedge b = \emptyset \) does not entail that one of the factors is zero, except in \( 2 \). Concatenation does (van Benthem 1991:244). Concatenation is associative, Boolean meet is also commutative. Both distribute with join. Join and meet are idempotent, concatenation is not. Concatenation closure (Kleene star) is.

There is a subclass of regular languages of particular interest here. That is the class of *star-free* languages. A *star-free* extended regular expression denotes a (possibly infinite) language obtained from finite languages with Booleans and concatenation. More explicitly, star-free languages are the closure of the following conditions:

\[
\text{unit } 1^* \text{ is star free}
\]

\[
\text{atom } a \text{ is star free}
\]

\[
\text{ef is star free when } e,f \text{ are}
\]

\[
\text{ef and ef are star free when } e,f \text{ are}
\]

\(^{16}\)Bybee et al (1994:160) make a distinction between *iterative*, which means repetition on the same occasion, and *frequentative*, which means repetition on different occasions. The difference can reflect difference between iteration of open vs. closed event types: *eat and eat* (continue to eat) vs. *eat often* (eat up repeatedly). The latter is a second order iteration given *eat* is already one.

\(^{17}\)An event \( f \) is a (right) identity relative to \( e \) (an idempotent) when \( ef = e \). For instance, \( a^*a = a \).
Infinite (co-finite) languages arise here from complementing finite ones. For instance, a* “only a’s” is denoted by the expression \( \neg(<a\prec) \), “no non-a’s”, where a is a concatenation atom. This description includes also \((a\cup b)^*\) ‘any number of a’s or b’s defined by \(\neg(<a\cup b)\). Another example of a noncounting language is alternation \((ab)^*\) definable as

\[
(ab)^* = \neg(b < U \cap a < U \cap b < U \cap a) = (a \cup b)^* \setminus (a \cap b)
\]

An example of a nondegenerate star is the language \((aa)^*\) of an even number of a’s. Star-free languages are noncounting. A regular event e is noncounting if there is a k such that for all x,y,z in \(1^k\), \(xy^kz \in e \text{ iff } xy^{k+3}z \in e\) (McNaughton/Papert 1971). A noncounting language only allows some maximum number or else any number of repetitions of any factor. Noncounting languages allow expressing “twice”, but not “an even number of times”. They can count up to a constant, but they cannot cycle the counter.

The alternating language \((ab)^*\) is star free, while \((aa)^*\) “an even number of a’s” is of star height one. Comparing the automata, one can identify the state from its transitions in the former, but not in the latter. Hence the former can be started anywhere in the string, while the latter must run from end to end. The former needs no counter, the latter does.

Noncounting languages restrict iteration to event types whose prime factors are of length 1 (Pin 1997:56) or whose cycles are permutation invariant (Mcnaughton/Papert 1971:§5., van Benthem 1991:§8.3). In terms of group theory, first order definable, star-free or noncounting languages is that subset of regular languages whose automata are aperiodic, i.e. have only trivial cyclic subgroups (of order 2). A finite automaton is aperiodic (group free) if there is an n such that for all states s and words w, \(sw^n = sw^{n+1}\).

The class of noncounting languages is also the closure of locally testable languages under Booleans and concatenation. Membership of a locally testable language can be decided in a finite window. Two words are indistinguishable in a window of width n if they have the same set of factors of length n. A locally testable language cannot distinguish locally indistinguishable words, i.e. if one is in the language then all are. An n-testable language is identical to its n-gram approximation.

The class of all regular languages is the closure of locally testable languages under homomorphism (Medvedev 1964, McNaughton/Papert 1971). The proof of Medvedev’s theorem is quite simple: it is based on the observation that the set of derivations (sequences of compositions of productions) of a finite state automaton considered as a production system (Salomaa 1973:26) is locally testable language. In other words: the set of traces of an automaton is locally testable, because all nonlocal dependencies are coded into (“remembered by”) the states.

Element b is a concatenation atom or nilpotent if b\(\cap\)bb = \(\emptyset\). Elements a, b are concatenation atoms if they are disjoint from their concatenations, i.e. a\(\cap\)a.b = a.b\(\cap\)b = b.a\(\cap\)a = b \(\cap\) b.a = \(\emptyset\).

Element a is concatenation open if a.a \(\subseteq\) a and concatenation dense if a \(\supseteq\) a.a. An open and dense element a = a.a is concatenation idempotent. A regular algebra is atomless (dense) relative to concatenation if a=b.b for some b for all a in it. Concatenation idempotent event types distribute over meet:

\[a \cap (b.c) = a.b \cap a.c\]

States are idempotent. For instance, if it rains through the show, then it rains through all numbers. Atomic (singular closed) events are nilpotent of order 2: trying to do them twice in a row fails.

**Relation algebra**

Relation algebra (Peirce 1870, Tarski 1941, Quine 19??, Suppes 19??, Maddux 1983, van Benthem 1991, 1996, Pratt 1992, Ladkin/Maddux 1993, Marx 2001) is to objects what regular algebra is for numbers. The formal difference is that relation algebra has converse \(\neg r\), also denoted by \(r^\perp\), while events in real life do not: what is done cannot be undone. Converse is self-inverse or an involution: \(\neg\neg r = r\).

My approach to relation algebra differs from the usual one in that I do not start from sets, but develop relation algebra directly on Boolean algebra. Relations get the type of \(2^e \rightharpoonup axb\) of mappings from the cartesian product of two Boolean algebras to the Boolean algebra of relations. We can thus consider a relation r as a Boolean function of pairs xy where xy \(\supseteq\) axb. From the Boolean point of view, the notations for

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18 For instance, the 3-testable language consisting of the word xry can be represented as the Boolean meet of the locally 2-testable languages x., x_, y, and y.
pair $ab$ and cartesian product $axb$ are synonymous (modulo the algebra we are in), for a pair is the cartesian product of two atoms.

Building relation algebra on Boolean algebra, I do not have to distinguish singular and collective instances of relations like touch by type. For instance, touch is a relation between wholes and their parts: when two regions touch, their boundaries, which are smaller regions, touch as well, but the relation need not distribute to all parts.

The relations in $2^{ab}$ form a Boolean algebra whose zero is the empty relation $\emptyset$ and unit $1$ the cartesian product $axb$. A binary relation $r = arb$ in domain and codomain object types $a$ and $b$ is a subelement of the cartesian product $axb$. Cartesian product is associative, so $(axb)xc = ax(bxc)$.

Some notations introduced below may look unusual but work out (Marx 2001:694). The equation $r = arb = a x r b$ means domain and codomain of a relation are idempotent on the relation. This convention is in agreement with natural language, where redundant arguments are commonly left out: eat eat is short for you eat it or somebody eat something x eat y.

Left and right projections of $r$ are in binary relations equivalently denoted by $a \backslash r$ and $r \backslash b$ and $a / r$ and $r / b$ respectively, and equal the quotients $r / b$ and $a / r$, respectively, thanks to the idempotence $r = arb$. Since product is associative and relation converse exists, projection to any subset of argument places can be defined.

Think of relation symbols $r$ as infix operators on object types. In particular, identity $=$ and cartesian product $\times$ are idempotent on object types so that the relations $a=a$ and $axa$ both reduce to the object type $a$, considered as a relation. The unity object type, the domain or universe $1$ ‘anything’ in particular a reduct of both identity $=$ and the universal relation $x$.

The identity relation is denoted as usual by $=$ and equals $1=1, 1=x, x=1, x=x, x=y, xx, x^2$ and is the relation algebraic identity $\emptyset ^* = 1^*$. The universal relation $x$ is the unit $1$ of relation algebra, also denoted by $1x1, 1^1, 1xx, xx1$ (where $1$ is unit of Boolean algebra), $xxx, xxy, _x_ _x_ _x_ _x_ _x_ _x_ _x_ , etcetera. $axb = a1b = ab$ because the cartesian product is uniquely determined by its domain and codomain. If $x$ is an absolute variable, $xr = x^br = rf1x = x^brx$, the difference being that $x$ gets bound to the domain of the relation in the first two cases and to the codomain in the other two.

A nonrelational absolute object type $a$ can be uniquely retrieved from, hence represented as a relation, the identity relation in $a$, designated by $a=a, a=x, x=a, a^2=x$, and many other variants. For absolute object types $ab, meet$ and composition coincide: $a \times b = a \parallel b$. Note also $a = [a^0] = 1$ $a^0 = a^0 1 = a^a = a^a$.

Absolute object types $a$ are also in one-one-relationship to their cartesian products $a^2 = axa$, equally designated by $a[1], a[1^2] and many other variants.

An absolute object type $a$ can also be uniquely represented by its test relation $a x 1$ or $1 x a$, or a relation which passes through objects of the given type $a$ and screens out the rest. This idea is applied in dynamic logic. (van Benthem 1996:69)

Conversely, relation tests $r^* x 1$ or $1^* r$ reduce a relation to an absolute object type. For instance, the relation test parent on $1^*$ is the property of being a parent of someone. The converse test $1^*$parent only fails for Adam. This is a binary version of Tarski’s cylindric operator (see section on relational algebra) For atoms, all three representations coincide.

The universal relation $1$ is a unit of composition for $1^r \circ 1 = 1$ iff $r > \emptyset$ (van Benthem 1996:66). In general, if $r = x y$, then $arb = a x r y b = (a \parallel x) r(y \parallel b)$. In particular $a^* r b = r$ where $a$ and $b$ are the domain and codomain of $r$. Thus we can consider the event type $arb$ as the composition of $a$, $r$ and $b$ as well as the meet $rf1xb$. Note also $axa = (axb)^a(xba)$.

Identity $=$ is an identity of composition, that is, $(= a r) = r = (r = =)$. Note also $1^r r = 1(x r^1)$ and $(1^r x) 1 = r^2 1$.

It was noted that absolute object types can be represented as degenerate cases of relations, either as diagonal or as cartesian product. Conversely, relation projections (domain and codomain) $1^r$ and $r^1$ can be represented as identity relations as follows:

$$1^r \text{ corresponds to } =_f x r^2 - r$$

$$r^1 \text{ corresponds to } =_f - r^2 r$$

The image of a relation $r$ under a given object type $a$ is represented by the composition $(a^2 r) 1 = ar^1$ and the inverse image under $b$ correspondingly by $1^r b$. For instance $1^r $love$animal$ contains those who love some animal (x: $x$ love animal). It is distinct from $(1^r $love$animal = (1^r$love$)animal$
which contains those which are animals and lovers. (Note that English animal lover can also mean either.) Image is continuous (preserves joins) so if $a = b \cup c$ then $a^0r = b^0r \cup c^0r$. Note the equivalences

$$(r^*s)^1 = (r^1s)^1$$

$$(a^0r)^1 = (a^1s)^1$$

(Kaplan/Kay 1994:342) The field $|r|$ of $r$ is the join of the domain and the codomain, the absolute object type $1^r \cup r$ is $\equiv |r|$ $\cup r$, equivalently its identity relation $|r|_r^1 = |r|_r^1$. The restriction or relativisation of $r$ to field $a$ is $r|^a$. is Positive powers of composition are defined by $r^{n+1} = r \circ r^n$.

Combining the conventions, we can derive the equation $r = r \cap axb = a^0r b$. In other words, a relational object type meets with the cartesian product of its domain and codomain and is the composition of its domain, itself, and its codomain. For instance,

$$\text{bite} \cap \text{dog} \times \text{man} = \text{dog}^0 \text{bite}^0 \text{man}$$

This is the restriction of the relation bite to dogs and men.

When the domain and codomain $a$ and $b$ are elements of Boolean algebras it also makes sense to talk about the dual of a relation $\neg(\neg a = b)$. The relation dual of inclusion $a \subseteq b$ is the opposite non-inclusion $b \not\subseteq a$. This can be compared to its quantifier dual some. The meet of all and some and not only is the default implicature of all. Inclusion $\subseteq$ is a preorder so $\subseteq^0 = \subseteq, = \subseteq^0$.

Here is a list of relation algebra operators. The second column indicates definitions of the operators in terms of transduction.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1$</td>
<td>$xy' : 1$</td>
</tr>
<tr>
<td>$=$</td>
<td>$xx' : x$</td>
</tr>
<tr>
<td>$r^*s$</td>
<td>$xy' : z' : xrz \cap z' : sy$</td>
</tr>
<tr>
<td>$~r$</td>
<td>$yx' : xry$</td>
</tr>
<tr>
<td>$r \div s$</td>
<td>$s^\circ r$</td>
</tr>
<tr>
<td>$r \to s$</td>
<td>$\neg(\neg r \circ \neg s)$</td>
</tr>
<tr>
<td>$r \leftarrow s$</td>
<td>$\neg(\neg r^\circ \neg s)$</td>
</tr>
<tr>
<td>$r^*$</td>
<td>composition closure</td>
</tr>
</tbody>
</table>

Composition has a dual called relative sum $r+s$ defined by $x \circ r \cap 1 \cap 1' \cap sy > \emptyset$, whose left and right adjoints are the relation quotients $r \cap s$ and $r \div s$ defined by $\neg r^\circ s$ and $s^\circ \neg r$. They obey $s \subseteq r \circ r$ and $r \subseteq r^*s/s$ respectively. For instance, after a wrong left turn, one way to go right is to back up and turn right.

Relation residuals, defined by the equations

$$r \leftarrow s = \neg(\neg r^\circ \neg s) \quad r \to s = \neg(\neg r^\circ \neg s)$$

are (right/left) adjoint to composition (Pratt 1997). Composition and its variants are characterised by Boolean relations between codomain and domain:

$$x r^\circ sy \leftrightarrow x r^1 \cap 1' sy > \emptyset$$

$$x r \to sy \leftrightarrow x r^1 \subseteq 1' sy$$

$$x r \leftarrow sy \leftrightarrow x r^1 \supseteq 1' sy$$
Residual and composition language a *modus ponens* (cut, cancellation, application):

\[ r^o(r \rightarrow s) \subseteq s \]

An example of right residual \( \leftrightarrow \) is the relation *do-want* between \( x \) and \( y \) in \( x \) does whatever is wanted by \( y \). Thus *do-want* is obey, and its converse \( \neg(\text{do-want}) \) is power. Power over opposites is control. The reflexive subset of that, by the Aristotelian definition, is *freedom*: A free agent does precisely what he wants, that is, obeys himself, or controls himself. (This does not have to prevent him from doing whatever others want, if they want what he wants.)

An example of left residual is the relation *enemy* between them and us *they hurt-help us* in whatever hurts them helps us. This relation holds symmetrically between the players of a zero-sum game, where in general I *oppose* you, whatever I want you don’t and vice versa: \( \text{I-want-want you}. \) The opposite relation *help-help* holds between aims \( p \) and means \( q \). The Latin proverb *quae nocent docent* is the reflexive left residual \( x \text{ hurt-teach x} \).

The dual of image and inverse image, respectively, is right and left residual \( \leftrightarrow \rightarrow \) and \( \rightarrow \leftrightarrow \). For instance, the residual \( \text{I love-man} \) contains those who love only men, or \( x: x \text{ love y} \rightarrow y \text{ man} \). This relation will reappear in connection with modalities. The relation *love-self* is loving oneself only. The relation property of almost reflexivity (quasi-reflexivity in van Benthem 1986) \( xry \rightarrow xrx \) may be characterised by the left residual \( r \rightarrow r^0 \).

Residual with respect to inclusion gives another idiom for agent and object nominalisations: *eater* is *whoever eats* \( \text{I eat} \) or \( r \subseteq \text{S and food is whatever is eaten} \text{ eat} \) or \( \text{I eat} \) or \( \text{eat} \rightarrow \text{S} \) or \( \geq \rightarrow r \).

Further relation properties can be characterised by considering instead of the usual *angelic* composition a dual of it, *demonic* composition \( \text{res} \) (Bergstra/Stefanescu 2007?). It is defined by

\[ x \text{ res } z \text{ iff } xry \leftrightarrow ysz. \]

(Asymmetric cases where \( \leftrightarrow \) is replaced by \( \leftrightarrow \rightarrow \) are called backward and forward demonic composition, respectively.) For instance, the demonic composition of a partial order with itself produces a lattice, and that of an equivalence relation (undirected graph) defines its equivalence classes.

Relation application is composition plus projection, thus for instance *my parents* is \( \text{P-parent} \). The relation *grandfather* is faithfully represented by the relation algebraic formula \( \text{father}^3 = (\text{parent} \cap \text{male}_2)^3 = \text{parent}^3 \cap (\text{male}_3)^3 \).

Relation algebra can be axiomatised with Booleans, relation composition (alternatively, cartesian product plus selection) and projection as a minimal base. The equational theory of relation algebra is finitely axiomatisable but undecidable (Pratt 1990, van Benthem 1996). It corresponds to the three-variable fragment of first order logic (Tarski/Givant 1987, van Benthem 1996:69). Compare also Kamp’s theorem.

Binary relation algebra is thus a proper subset of first order logic. With only three variables, one cannot express relations among four objects (Marx 2001). Relation algebra extended with variables regains the power of first order logic. For example the four-way relation *sibling* of two children sharing two parents is represented in relation algebra with variables as

\[ \not\exists x (\neg \text{parent}^x \text{ parent}^x \text{ parent}^x \not\text{parent}^x \text{ (x \not\exists \text{parent})} \]

Putting it into English, one’s full sibling is another child of one’s parent’s child’s other parent, or

\[ \text{sibling} = \text{other child of parent of child of other parent} \]

This is not the way we usually say it, given the much simpler plural idiom *siblings share parents*.

Relation algebra with complete join or Kleene star (Jónsson/Tarski 1951) includes regular algebra as a special case. (In fact, regular algebra is complete relation algebra without conversion.) Accordingly, its expressive power goes to second order. Recursive relations like *ancestor* become definable as *parent*.

The composition closure has the usual properties of Kleene star, including

\[ r \cup r^* = r^* = r^{**} \]
\[ (r \cup s)^* = (r^*, s^*)^* \]

Regular algebra can be represented in complete relation algebra by formalising events as regular relations instead of regular languages. A change is a relation between two states or courses of events. Let each event \( e \) be represented by the transducer \( xe:x \) which continues a course of events \( x \) with event
e. The transduction relation defines a binary relation between courses of events. The translation defines an isomorphic embedding between relation algebra and regular algebra which preserves Boolean and regular operations (van Benthem 1991:242).

**Relational algebra**

Relation algebra can be extended to many-place relations by letting the cartesian product of relations iterate. Cartesian product of relations $\times$ is associative. A many-place relation $\times$ can be considered a two-place relation between any partition $\times$, $\times$ into domain and codomain object types. (This is currying for the monoidal category of relations).

Codd’s (1972) $n$-place relation algebra, or *relational* algebra rearranges the interrelationships between relation composition, concatenation, cartesian product, and meet. It singles out composition (a special case of relation join) from cartesian product using selection (meet) and projection: select $x,z$ from $r,s$ where $rxy = sxy$. Thus composition $\circ$ is defined in terms of cartesian product, identity, meet and projection. Borrowing transductor notation, if $r = \{a\}$ and $s = \{c\}$, then

$$r^a s = \{a\} : (r \times s) \cap \{a(b=c)d\}$$

which is the relation obtained by projecting the domain $a$ and codomain $d$ columns out of the result of selecting from the cartesian product of $r$ and $s$ the rows where codomain $b$ of $r$ and domain $c$ of $s$ agree. In particular $arl \cap lsb = arf \cap sb$ and $arl \cap lrb = arb$. To hit somebody and for somebody to get hurt in one go is to hit and hurt somebody. The two-place relation hit is the meet of the one-place relations be hitting and be hit.

Another algebra of $n$-place relations is Tarski’s *cylindric algebra* (Henkin et al. 1971, 1985). It contains Booleans, identity (diagonal) relation $x = y$ and a relational operation of *cylindrification*, in effect existential quantification. Cylindrification $\mathbf{cyr}$ is the n-ary counterpart of test relation, described in the previous section. It can be defined as

$$\mathbf{cyr} = rxyz > \emptyset$$

For instance, binary relation conversion is captured in cylindric algebra by representing a binary relation $\times$ as a cylindrified three-place one $\mathbf{cxy}yz$ and the converse relation as $\mathbf{cy}(x=y)\times(x=z)\times(yz)$. This is natural language passive: first copy subject $x$ to a free oblique position $z$, then cylindrify (delete) subject $x$, then copy object $y$ to subject and delete object.

Cylindric algebra like Codd’s relational algebra defines all first-order definable relations (Van den Bussche 200?).

Natural language is good at packing relations. *She gave me of the tree and I did eat* is the three-place composite relation $x$ give $y$ for $z$ to eat of the relations give and eat. We shall sort out how this sort of event types are built up from binary relations in the style of *she cause apple go adam go eat*.

Relational algebra gives a new perspective on the interdefinability of order relations and choice functions. For instance, the animacy hierarchy says human<animal<object. This formula can be interpreted as a cartesian product of the three object types. At any point, it can be split into two sides, so it matches the relation algebra expression animate\textasciitilde animate. From a regular algebra point of view, the comparative concept animate represents a prefix and animate a suffix of the order relation.

In the choice set of the man Bill and his donkey Sue animate assigns Bill to the animate end of the hierarchy and Sue to the inanimate end. Formally:

animate \textasciitilde animate \cap \text{human.animal} = \text{human.animal}

Relational algebra and regular algebra are related by the equation

$$\text{regular algebra} = \text{relational algebra + composition closure – converse}$$

**Function algebra**

Function application can be defined in relation algebra. Consider a one-place function in postfix notation $xf = y$, or (in the more usual prefix notation) $y = fx$ as a two-place relation $\mathbf{xfy}$. In prefix notation $y = fx$ denotes the codomain $xfy = xfa$ of the relation $f$. It is the same as $(x, \cap f) \cap x$, or the suffix of the meet of $f$ with the cartesian product of $x$ with the universe. The match is better if relations and functions are written in the same sense $xf = y$. I use both notations when need arises, so $yf = x$ equals $y = f^\times x$. 
A many-many relation \(afc \land afd \land bfc \land bfd\) can be represented one-one by a meet of joins of equations \((af = c \lor af = d) \land (bf = c \lor bf = d)\), enumerating the functions which are included in the relation. It can equally be represented as the Boolean relation \((a \cup b)\{c \cup d\}\) which equals the equations \((a \cup b) = (c \cup d)\) and \((a \cup b) = f^\prime(c \cup d)\), or by one-way distributive variants \((af = (c \cup d) \land bf = (c \cup d))\). (Salomaa/Yu 2000).

In this section I consider the algebra of functions \(h: A \rightarrow B\) from one Boolean algebra \(A\) to another \(B\). Such a function \(h\) is a **Boolean morphism** if it preserves Booleans, among them

\[
\begin{align*}
h(\emptyset) &= \emptyset \\
h(1) &= 1 \\
h(x \cup y) &= h(x) \cup h(y) \\
h(x \cap y) &= h(x) \cap h(y) \\
h(x') &= h(1 - x) \\
(x \subseteq y) &= (hx \subseteq hy) \\
\end{align*}
\]

For instance, the Boolean quotient \(a \cap b\) of \(a\) with \(b\) is a Boolean morphism.

For another example, an atomic object type like \(l\) is dually represented by an atomic Boolean morphism from **people** to \(2\) which returns \(1\) for me and \(\emptyset\) for others. The algebra of Boolean morphisms in \(b^a\) is a Boolean algebra with the constant function \(\emptyset\) as zero, the constant function \(1\) as unit, and the Boolean morphisms of atoms as a base.

Many mappings are not Boolean morphisms. Distribution properties are systematically related to quantifier profile. For instance **touch** is a topological (existential-universal) predicate which does not distribute over arbitrary meets. Objects can touch without all of their parts touching. Weaker conditions may hold. A **filter** preserves meets and inclusions, an **ideal** joins and subelements (van Benthem 1986:52).

\[
\begin{align*}
h(x) \cup h(y) &= h(x \cup y) \\
h(x \cap y) &= h(x) \cap h(y) \\
h(x') &= h(1 - x) \\
\end{align*}
\]

If \(h\) is an endomorphism, conditions like the following can be considered.

\[
\begin{align*}
h(x) \subseteq x \\
hhx \subseteq hx
\end{align*}
\]

A necessary and sufficient condition for distributivity is that the mapping be a positive Boolean morphism, continuous on joins and meets and monotone on inclusion (Jónsson/Tarski 1951, Keenan/Faltz 1985, van Benthem 1991). Most mappings do not preserve complements, for instance, parents of men do not exclude parents of women. An **injective** morphism preserves disjoint joins and complements; for instance men’s heads are not women’s heads.

A binary relation \(r\) is a Boolean function from pairs \(ab\) to \(2\). The class \(2^b\) of Boolean functions between two Boolean domains is much larger than the class \(2^{ab}\) of binary relations in it. Distributivity conditions reduce the former to the latter, letting Boolean functions represent, or **reveal**, relations.

A binary relation \(r\) can also be viewed as a function that maps domain to codomain by the projection or (co)image function \(p_y = 1^y = x: xry\), for instance the teachers \(x\) of a class of schoolchildren \(y\), or \(x = x'y = y: xsy\), for instance the students \(y\) taught by a team of teachers \(x\). This is the natural language process of **nominalisation** by which the verb \(x \text{ parent}\) \(y\) goes to the nominalisation \(x \text{ be parent of } y\).

Constraints on functions reveal interesting special cases of relations. Here is a short list:

\[
\begin{align*}
x \subseteq \rho x & \quad \text{ reflexive} \\
pxp \subseteq \rho x & \quad \text{ transitive} \\
p^\rho \rho x \subseteq x & \quad \text{ symmetric}
\end{align*}
\]

More correspondences have been identified in choice function theory (Fishburn 1977, cf. dyadic conditional modal logic Hansson 1969, Chellas 1975, Spohn 1975, van Benthem 1977, Carlson 1994). A choice function is a Boolean function. whose values are subsets of the same set:

\[
\sigma x \subseteq x \quad \text{ choice function}
\]

A binary comparative relation is revealed by a choice function which selects from any set of options those that are **good, better, or best** (Fishburn 1977). Alternative statements for conditions on choice functions include
Symmetry is also idempotence of may and involution of 1. Modal logic can be extended with variables and variable binding operators on indices (hybrid modal logic, Marx 2001). The idea of bindable modalities has been repeatedly introduced in tense logic, modal logic and relation algebra (Rescher/Urquhart 1920, Vlach 1973, Blackburn 2000, Marx 2001). It

\[ \sigma x = \emptyset \text{ only if } x = \emptyset \]
\[ \sigma (\sigma x \cup y) = \sigma (\sigma x \cup y) \]
\[ \text{serial} \]
\[ \text{transitive} \]
\[ \text{transitive (aka path independence)} \]
\[ \text{co-transitive} \]

Setting \( \sim \sigma \) for \( \sigma \) in the last condition shows it to be a dual of the previous one. Combining all conditions gives an equivalence relation, which reduces choice function to meet so that. \( \sigma x = \mathfrak{p}(x) \) for some type \( p \). (This is the defining property of an absolute adjective, Kamp 1975, Klein 1982, van Benthem 1991). Properties of choice functions correspond to axioms of basic conditional logic (van Benthem 1986:94).

One application of Boolean functions is (algebraic) modal logic. Here \( \text{may} \) and \( \text{must} \) are one-place functions on a Boolean algebra satisfying the conditions

\[ \text{may} \emptyset = \emptyset \]
\[ \text{must} 1 = 1 \]
\[ \text{may} (p \cup q) = \text{may} p \cup \text{may} q \]
\[ \text{must} (p \cap q) = \text{must} p \cap \text{must} q \]
\[ \text{may} p = 1 \setminus \text{must} (1 \setminus p) \]
\[ \text{must} p = 1 \setminus \text{may} (1 \setminus p) \]

Then there exists a unique binary relation \( r \) on 1 so that \( \text{may} p \) is the relation image \( 1 \rightarrow p \) and \( \text{must} \) \( x \) is its dual, the residual \( 1 \rightarrow r \rightarrow p \). The following conditions are equivalent (Jónsson/Tarski 1951, Hughes/Cresswell 1968:§17, Bull/Segerberg 1983:11):

\[ p \subseteq \text{may} p \]
\[ \text{must} p \subseteq p \]
\[ \text{r is reflexive} \]
\[ \text{must} p \cup q = 1 \]
\[ \text{may} p \cap q = p \cap \text{may} q = \emptyset \]
\[ \text{r is symmetric} \]
\[ \text{may} \subseteq \text{must} \]
\[ \text{must} p \subseteq \text{must} p \]
\[ \text{r is transitive} \]

Combinations of these conditions define well known modal logics. None gives normal modal logic \( K \). Reflexivity gives \( T \). \( S4 \) matches preorders. \( S5 \) matches equivalence relations. Symmetry is also characterised by the Brouwerian \( B \) axiom \( \text{may} \text{must} p \subseteq p \) or its dual \( p \subseteq \text{must} \text{may} p \).

The weaker the logic, the more iterated modalities can be distinguished. \( K \) and \( T \) distinguish all (Hughes/Cresswell 1968:70). \( S4 \) distinguishes fourteen (sixteen counting \( p \) and its negation). These are all the alternating sequences of the language \( (\text{may}\mid \text{must})^{2} \) of at most three modals. Other sequences reduce due to the idempotence of the modalities \( \text{may}, \text{must}, \text{may must} \) and \( \text{must may} \).\(^{19}\) \( S5 \) only distinguishes two: \( \text{may} p \) and \( \text{must} p \) (six if we count in \( p \) and the negations). In a sequence of modals, only the innermost counts. (Hughes/Cresswell 1968:48).

Given reflexivity, \( \text{must} \) defines a morphism of event types. The algebra of \( \text{must} \) is not closed under joins or complements so it does not form a Boolean algebra.

\[ \text{must} (1 \setminus p) \subseteq \text{must} (1 \setminus q) \]
\[ \text{but not vice versa} \]

Knowledge can be represented as a reflexive modality (Hintikka 1975). The modal logic \( S4 \) of partial order forms the intuitionistic Heyting algebra (Gödel 1933). This makes formal sense of the idea that what one knows is a partial image of what happens. (Cf. information set in game theory.)

Choice functions also allow characterising weaker modal logics than \( K \). Classical modal logic only preserves equivalence. Regular modalities preserve inclusion but do not distribute over join or meet. The dynamic modalities \( \text{able/happen} \) are an example. Their logic matches that of the \( S4 \) existential-universal modalities \( \text{may must} \) and \( \text{must may} \), respectively (Segerberg 1971, Carlson 1994).

The difference between relation algebra and modal logic by Boolean function algebras is one of perspective. It is the same classical logic in different wrappers. (van Benthem 1996).

Modal logic can be extended with variables and variable binding operators on indices (hybrid modal logic, Marx 2001). The idea of bindable modalities has been repeatedly introduced in tense logic, modal logic and relation algebra (Rescher/Urquhart 1920, Vlach 1973, Blackburn 2000, Marx 2001). It

\(^{19}\) Other languages which produce the \( S4 \) operators are (\( \neg \text{may} \))\(^{4} \) and (\( \neg \text{may} \))\(^{4} \). subject to idempotence of may and involution of \( \neg \).
is available in event calculus as well. For instance, transitivity of time is expressible in hybrid tense logic as

\[ \text{fut (fut (then (now (fut then)))} \]

which says that two hops to the future can be also made by one hop. But the statement of the same fact in regular events looks a lot simpler.

\[ \lllll = < \]

A general calculus of functions is lambda calculus or combinatory logic, of which later.

**Transduction algebra**

What I call transduction algebra is in turn a relational algebra of regular algebras (or the other way round). Formally, it is no different from relation algebra or regular algebra, all the operators of the former two have natural equivalents here. The transduction product \( : \) is a notational variant of concatenation or (cartesian) relation product.

The left side of the transduction relation represents the input language of the transducer and the right side its output language — or the other way round, the direction is a matter of perspective and grammatical choice. Variables \( x \) range over event tokens in a shared alphabet between the input and output languages, so that they stay fixed in the transduction.\(^{20}\)

In this section, I denote transduction composition by whitespace. The left and right projections of a transduction will be denoted as \( a ^:\b b \) and \( a ^:\b \). If \( r = x\cdot y \) is a transduction, then \( a ^ r = 1 ^{r} (a \cdot r) \) and \( ^r \cdot r = (r \cdot b ^1) \) are its left and right images (Kaplan/Kay 1994:340). The abstraction operator \( ^{\cdot} \) relates to transduction as projection relates to product, i.e. abstraction and transduction are adjoint.

As a notational variant of concatenation or relation product, transduction product \( : \) is associative, so \( e : (f : g) = (e : f) : g \).

The identity transducer \( x : x \) is not the same as the forgetful transducer \( 1 : 1 \) which stands for the universal relation. \( 0 : 1 \) and \( 1 : 0 \) are final and initial elements for composition, respectively. Note also the transducers \( e : 1 \) or \( e : x \). The two are equivalent and denote the constant mapping to \( e \), so \( e : 1 = e \).

Composition with \( e \) is equivalent to \( e : 1 \cdot 1 : x \).

I use \( \circ \) or whitespace to represent composition of transducers. The class of transducers is a concrete category with the class of event types as objects and transducers as arrows. In fact, transducers form a group under composition with the identity transducer \( x : x \) as the composition identity. Transducers are arrows for events and objects for composition. Events are dual to transducers, transduction (abstraction)

\[^{20}\]To define proper substitution of variables \( F \) in \( G \), the transduction must respect the tree of subevents. Regular tree transducers generate context free string languages. Any recursively enumerable language can be defined as a meet of context free languages. With the abstraction operator, the event calculus reaches the power of lambda calculus, regular unification grammar, or Turing machines (Rozenberg/Salomaa 1997).
Composition is characterised by

\[(e:f) \circ (g:h) = (e:h):(f\cap g) \circ (f\cap g):h = (e:h):(f\cap g)\]

from which follows the cancellation law

\[e:f \circ f:g = (e:g):f\]

and further, the inverse law

\[e:f \circ f:e = (e:e):f\]

Another principle governing transduction and composition is

\[(e:f) \circ (g:h) = (e:h):(f:g) = (e:h):(e:f):(h:g)\]

In particular, then, we get for composition

\[(e:f) \circ (f:g) = (e:g):(f:f) = (e:g):(e:f):(g:f)\]

and inverse

\[(e:f) \circ (f:e) = (e:e):(f:e):(e:f)\]

The following connection between the abstraction and transduction interpretations of : is obtained from the above.

\[x:y \; e = x:y \; e:e = x:(y\cap e) \; (y\cap e):e = x:y\cap e \quad e:e = x:y\cap e\]

Meet and composition (both fibred products) come down to the same when the law constraining composition is vacuous.

For instance, \(axb:cxd\) applied to \(aeb\) where \(a\) and \(b\) are concatenation atoms gives \(ced\), for \(aeb = 1:aeb\), and composition \(1:aeb \circ axb:cxd\) yields \(1:aeb\cap axb\cap aeb\cap axb:cxd = 1:aeb\cap aeb\cap ced = 1:ced. = ced\).

Varieties of transduction are graph rewriting and tree transduction (Comon et al. 2002). In general, transductions with variables are not linear or regular. A simple example is \(x:xx\), which represents the copy combinator, or copy language. The restriction of tree transduction to linear terms with one occurrence of each variable per event type is regular (Comon et al. 2002).
relations. More specifically, regular transductions are the closure of atomic transductions of form \( a:b \) and \( \emptyset^*:b \) under inverses and regular operations. In other words again, they are regular languages over the alphabet of pairs of atoms or \( \emptyset^* \). (Roche/Schabes 1997). The class of regular languages is closed under finite transduction (Rozenberg and Salomaa 1997:88), and so is the class of regular relations. Regular relations generalise straightforwardly to \( n \)-place relations, with regular languages as one-place. (Kaplan/Kay 1994).

The class of regular transductions is closed under concatenation, inverse, union and composition, but not under complementation or meet if the languages include \( \emptyset^* \) (Rozenberg/Salomaa 1997, Roche/Schabes 1997). A simple counterexample is the event type

\[
(a:b)^*(\emptyset^*:c^*) \cap (\emptyset^*:b^*)(a:c)^* = \\
(a:b.c^*)^* \cap (a:b^*.c)^* =
\]

\( a^n:b^*c^n \)

which transduces any number of \( c \)'s into an equal number of \( a \)'s and \( b \)'s (Kaplan/Kay 1994).

Any binary regular relation \( r \) is of form \( r = e:f \) for some regular expressions with variables \( e,f \). There is a rewrite of \( r \) in the form of a regular expression over the pair alphabet \( (1^0+\emptyset^*:1^0+\emptyset^*)^* \) (a path language for \( r \), Kaplan/Kay 1994:343). \( r \) is a same-length relation iff it has a rewrite in the alphabet \((1^0:1^0)^*\). Same-length relations are closed under meet and complement (Kaplan/Kay 1994:343) so they are regular languages over an alphabet of pairs. So are relations with an upper bound to the differences of the lengths of strings in the relation. Any regular relation is also equivalent to a regular language and a pair of monoid morphisms from it to the input and output. (Comon et al. 2002:174).

More interestingly, star free regular relations are closed under meet and complement. This should follow from the formism between regular relations and relational algebra, which is closed under complement. A rational relation is star free if and only if it is aperiodic and deterministic. Star freeness is decidable for deterministic rational relations but undecidable for nondeterministic ones (Madona/Varricchio 1994).

Events which go backwards in time can be represented by formalising events as regular relations instead of regular languages. Here is one way: let event \( e \) be represented by the transducer \( xe:x \) which suffixes a course of events \( x \) with event \( e \). It is easy to see that this translation preserves the properties of concatenation, now represented by composition of transducers. Define the inverse event \( e^{-1} \) of event \( xe:x \) as the inverse transducer \( x\bar{e}e \). It is easy to see that \( ee^{-1}x = e^3ex = x \). Compare also two-way finite automata (Hopcroft/Ullman 1979:36).

Inverse events which go backward in time undoing real events provide a denotation to \textit{after} as the inverse of \textit{before}. Under this extension, \( \times \) is just the the event type \( e^{-1} \). Imaginary events have a use in counterfactuals. They help make formal sense of the metaphor between past and irrealis: adding an event moves time forward, while adding the inverse of an event (subtracting an event) moves time backward. This allows interpreting past future tense \( \times e \) literally as the replacement of one course of events with another.

Aspect and diathesis operators can be construed as transducers on event types. Since transducers form a monoid under composition, optionality and iteration make sense on event types transducers. For instance, \( pf? e \) can be defined as \( pf \in (e \cup e) \) and \( pf^* e \in pf \cup pf e \). In fact, we can define a nested context free event type in this manner as \( (\neg ax = a:x) \) \( ax \). It is the fixpoint of the recursive event type equation \( x = \neg ax = a \cup a \).

\textbf{Abstraction}

The \textit{abstraction operator} \( x':y \) is left projection of the transduction operator (\( 1 \)). It is a variable binding type abstraction (lambda) operator resembling a natural language relative clause \( x':e \) ‘the \( x \) such that \( e \)’. Strictly \( xe \) denotes a relation between types and \( x':e \) its left domain. In practice, I leave out the projection operator ‘ from \( x':e \) much of the time.

The abstraction operator allows denoting the lefthand type of events that satisfy the righthand type. Or vice versa; the direction is a choice of grammar. The right to left reading for the operator is more natural for head-initial prefix languages like English. Sometimes it is more iconic to work left to right as in postfix or suffix languages (see section on transduction).

In lambda calculus, \( \lambda x.e \) denotes a function which returns whatever \( e \) denotes for any \( x \). The application \( \lambda x.e \ x \) denotes the same as \( e \). If \( e \) is a truth function, \( \lambda x.e \ x \) denotes true or false according as \( x \) satisfies \( e \), so \( \lambda x.e \) can be dually construed as denoting the set \( e \) is the characteristic function of. Event type abstraction \( x:e \) on the reading just suggested is an inverse dual of lambda. It denotes a
subtype of x, not e. It need not be applied to anything to do so, for it will turn out equivalent to the composition x' = e.

With the abstraction operator we can define projections on an event, the prefix and suffix e/f = e\langle ex\rangle f and e/\emptyset = f(e\langle xf\rangle f) which single out a typed beginning and end of an event, respectively. The double slash distinguishes these operators from the left and right quotient operators e/\emptyset = xex\langle xf\rangle f and e/f = xex\langle xf\rangle f (Salomaa 1973), which subtract a typed beginning and end, respectively. An untyped beginning of an event e can be written as e/\emptyset or \langle e/f and the end as \langle l/e or e/\emptyset. The complement of the prefix \langle l/e contains medial and final events x:(e/\emptysetx) or in e\langle l/e. Proper medial subevents are in \langle l/e\emptyset or in e\langle l/e\emptyset e/\emptyset. (For see section on ideals and filters.)

Further useful shorthands are Perl style left and right abstraction operators e/\emptyset = e:ef and e/\emptyset = f:ef for events immediately preceding and following given events.

Parentheses bind tighter, then comes dotless concatenation. Beyond that, one place operators bind tighter than two-place ones. Among operators of the same arity, other operators bind tighter than Booleans. Of the unary operators, the (relatively) basic ones bind more tightly than defined ones, and ones abbreviating intersection less tightly than the others.

The abstraction operator allows two event types to be equivalent (entail one another) but denote different things, for instance the projection and quotient operators are equivalent to ef but denote various parts of it. We might call the part denoted by the bound variable x focus (foreground) and the rest presupposition (background). The abstraction operator also allows representing disconnected event types and partially ordered courses of events.

An important insight captured in this formalism is that events combine by concatenation and meet, both of which associative operations. Associativity provides for the categorial ambiguity or polymorphism characteristic of natural language.

Meet is essential in that it allows the event calculus makes sense of superposition of events in addition to event concatenation and composition. Superposition allows us to do justice to the redundancy of natural language coding of events. (Unification in situation semantics is another instance of superposition, Cooper 19??.) There is another duality here between an atomic, compositional view on events and an atomless, superpositional one.

Altogether there are at least four ways to compose events: superposition, concatenation, composition and substitution, formalised by Boolean algebra, regular algebra, relation algebra, and transduction algebra, respectively.

**Substitution**

A substitution e(x|y) of y for x in z in general can be decomposed into addition of y and deletion of x. Conversely, addition can be defined as substitution for identity and deletion as substitution by identity.

Addition of y to x gives xy, which followed by deletion of x leaves over y. Function application defined through relation projection is also an instance of substitution, and vice versa. They are the same thing under different descriptions.

A monoid morphism is a function (substitution) which preserves concatenation: x' = y, z' = z otherwise, (xy)' = x'y'. The last clause is the distribution law which extends the homomorphism. Distribution is the algebraic law of a morphism.

Proper substitution of values to variables as defined in logic combines the following two ideas:

(i) substitution is not a string (monoid) morphism, but a tree morphism which preserves both horizontal order (concatenation) and vertical order (dominance). It is defined inductively by complexity of formula, not just on atoms and concatenation.

(ii) The substitution must be proper, so that free variables do not get bound. A variable gets bound when two variables which were different become the same. In terms of morphisms the substitution is one-one on variables. There condition that the mapping is one-one is an higher order statement. What it entails locally is the following equation:It is defined like this:

\[ x.(x|y) = x\langle x.y = \emptyset^*.y = y \]

substitution consists of addition and deletion.

---

21Mnemonics: event type over the line is what the event type denotes, the order of the events is iconic. Note that e = f\langle x = e/f = (e/\emptyset)(e/\emptyset) and e/\emptyset = f/\langle f/\emptyset).

22This usage of focus is in agreement with e.g. Rooth (1992). Cf. also focality in Johansson (1998).
$z.(x\cdot y) = z(1\cdot 1) = z$
$x = 1$ when $e$ is linear in $x$

$(x:e).(x\cdot y) = x(x\cdot y):(e(x\cdot y)) = y:(e(x\cdot y))$

$(x:e).(x\cdot y) = x:e$
Otherwise

Here $x:e$ and $y:(e(x\cdot y))$ are *alphabetic variants* if the latter is not empty.

The key part of condition (ii) is the principle $x = 1$ applied in the second clause of the above definition. It holds for *linear* terms which contain only one occurrence of variable $x$ (Comon et al. 2002:13). The equality fails for nonlinear event types which contain shared variables. Although $xx \subseteq 1$ is true, the converse does not hold. As a result a proper substitution fails to cancel out if the substituend contains the substitution value. For instance,

$$(xy)(x\cdot wyz) = (x.(x\cdot wyz).(y.(x\cdot wyz)) = (x\cdot wyz) . y.(x\cdot wyz)$$

There is no way to get rid of the remaining substitution term when it shares variables with the substituend (Curry/Feys 1958:94, Stoy 1977:62).

The notion of substitution has wide application. Any mapping, for instance a change of place, is a substitution in this generalised sense. Multiplication by an element $a$ of a field by the fraction $b/a$ or the additive term $b-a$ carries out a substitution of a with $b$. The replacement operator of Karttunen (1994, 1995) defines regular substitution. *Except* thus codes a Boolean substitution or replacement.

The key algebraic notions *function*, *substitution*, *morphism*, *variable*, *abstraction* and *combinator* are interdefinable (Curry/Feys 1958:86, Barr/Wells 2002). Quantification involves Boolean inequality and binding. Monadic quantification does not need variables, it is captured by Boolean (in)equalities. The notion of Boolean unit already involves quantification, being a closure.

Binding entails coreference, shared variables denote the same. Binding is related to substitution for $x rx$ > $\emptyset$ means $xrx$ has a nonempty substitution instance. Variables and binding are also interchangeable with combinators, which do the copying and deletion needed for substitution.

Variables involve morphisms. Substitutions are morphisms, and proper substitution characterises variables. $I r l$ is of the same form as $x rx$. The difference is proper substitution. Each occurrence of the Boolean unit $1$ is freely substituted for by the inequality $a \subseteq 1$, which expresses existential generalisation. $xrx$ is instantiated by doing proper substitution, i.e. $x r x.(x\cdot a) = x(x\cdot a).r(x\cdot a).x(x\cdot a) = ara$. This is a morphism. It is also a transduction, for the substitution $(x\cdot a)$ is a notational variant of the transduction $x:a$.

**Combinatory logic**

Combinatory logic (Schönfinkel 1924, Curry/Feys 1958, Hindley/Seldin 1986, Quine 1966, 1971, van Benthem 1986;59, 1991) is a variant of functional (lambda) calculus which eliminates variables and parentheses in favor of operators called combinators. Combinators operate on left associative sequences of objects. The result of an *application* of a combinator is a sequence made out of some of the objects it combines (possibly with repetitions). Combinatory logic combinators replace variables and parentheses with operators in Polish notation.

Combinators can be classified by what they do to arguments. An identity is just a placeholder that does nothing. A composition adds or removes parentheses. A variation copies or permutes arguments. Specifically, a permutation permutes arguments, a duplication repeats some arguments, and a cancellation (or projection) selects some arguments and drops others.

One fascination of combinators is that they open an algebraic perspective on grammatical operations such as deletion, copying, permutation, and distribution of symbols. This helps recognise and exploit analogies between differently interpreted, but structurally similar domains.

The best known combinators include the following.

<table>
<thead>
<tr>
<th>translation</th>
<th>axiom</th>
<th>associated algebraic ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I$</td>
<td>$x:x$</td>
<td>Identity</td>
</tr>
<tr>
<td>$K$</td>
<td>$x:xy$</td>
<td>left projection, right cancellation</td>
</tr>
<tr>
<td>$C$</td>
<td>$xzy:xyz$</td>
<td>inversion, permutation, commutativity</td>
</tr>
<tr>
<td>$W$</td>
<td>$xxy:xy$</td>
<td>duplication, copying, idempotence</td>
</tr>
<tr>
<td>$B$</td>
<td>$x(yz):xyz$</td>
<td>composition, associativity</td>
</tr>
</tbody>
</table>
Combinators have been proposed as a way systematising observations about natural language diathesis (Curry/Feys 1958:§8S2, van Benthem 1991:47,128). This idea will be pursued below. For more details on combinatory logic, see Appendix.

Linear algebra
Choose a set of dimensions, say, event type, participants, time and place and construe events as a product space of the dimensions each considered as Boolean algebra:

\[ \text{event} \subseteq \text{type} \times \text{objects} \times \text{time} \times \text{place} \]

This representation opens up a way of looking at events as a linear algebra or vector space. The representation of events in time through regular expressions is a one-dimensional projection of this idea onto time. Any partition of the space into two sets of dimensions mapped to a third can be interpreted as a Chu space (Pratt 1997, 1999).

The Boolean product space of events can also be considered a linear algebra or vector space with scalars in \( \mathbb{2} \).

Boolean operations in the product algebra are taken componentwise. For instance, \( \text{rain} \setminus \text{yesterday} \) abbreviates the componentwise meet of a vector whose type field is \( \text{rain} \) and all other fields \( 1 \) and another whose time field is \( \text{yesterday} \) and other fields \( 1 \). The former denotes the event type \( \text{rain} \) which includes all tokens of rain, the latter the event type \( \text{yesterday} \) all tokens yesterday. This is the duality of vector spaces and linear algebra.

\[ \text{rain yesterday} = \text{rain}_- \setminus \_\text{yesterday} \]

The duality of vector spaces and linear equations is one of the key ideas here. It also explains why it is that natural language so freely equivocates between Boolean \( \text{and} \) and concatenation \( \text{and} \text{then} \). See appendix.

Monoids and groups
There is work for group theory in this as well. There is a group theoretic duality between cyclicity and iteration (McLane/Birkhoff 1967:81). An iterated event goes round in a cycle. The smallest cyclic group is the one-element group of order 1, the unit, followed by groups of order 2 (reflexivity, idempotence, Boolean algebra), 3 (symmetry, converse, involution), and 4 (transitivity). The Klein four group is the product group \( 2 \times 2 \).

The cornerstone of the algebraic theory of machines is the observation that any finite monoid can be seen as a finite state machine and that recognition of regular languages reduces to multiplication in a monoid. More formally, a finite monoid \( M \) recognises a language \( L \) if there is a monoid morphism from \( L \) to \( M \). Kleene’s Theorem can then be stated as follows: a language is regular if and only if it is recognized by a finite monoid (Pin 1986, Beaudry et al. 2001).

The duality is put to use in the language-automaton translatability. Group theory allows distinguishing first order definable, star-free or noncounting languages as that subset of regular languages whose automata are aperiodic, i.e. have only trivial cyclic subgroups (of order 2).

To put it simply, the automaton for the event type \( a^* \) consists of one cyclic arc \( xax \) from a state \( x \) to itself, which is, the graph of a reflexive relation. In fact \( a^* \) can be viewed as a reflexive transitive relation in \( a \):

\[ a^* = aa^* = a^*a = aa^*a = a^+ \]

The term reflexive means ‘bent back’. We tend to understand reflexivity through symmetry and transitivity. Transitivity plus symmetry imply reflexivity. Translated into event talk, a symmetric cycle keeps us in the same state by chaining an event and its inverse. Cyclic events produce open event types. I shall point out phenomena where languages switch between reflexivity and iteration (see section on reflexives).

Category theory
For Aristotle categories were the most general concepts, their logical properties and relations. Modern category theory retains the spirit of this enterprise. Category theory or abstract or universal algebra (empty set theory for some) takes morphisms, or arrows (structure preserving mappings) between structures (called objects) as the primitive notion instead of sets. A category consists of objects and arrows between them. A category is a monoid of arrows under composition (of arrows). A category is a
subcategory if there is an injective morphism that inserts it into the supercategory. A full subcategory keeps all the morphisms of the supercategory.

An initial object of a category is the object from which there is just one arrow to any object. A final or terminal object is the object to which there is just one arrow from any object. In the category of Boolean algebras, 2 is initial and the free Boolean algebra on a set of generators terminal.

![Figure 2](image2.png)

Category theory is built round commutative diagrams and dualities. A commutative diagram is a graph of objects and arrows that commutes when two paths lead to the same object. Given two objects and an arrow between them, find a third one and arrows to it from both so that the diagram commutes. The third object is a colimit if it is the initial object of the category (or co-cone) of such objects. Here is what Parmenidean megista gene, the different modes of being (existence, inclusion, identity, unity) have in common. In category theoretic terms, the various senses of be are initial or terminal objects of interrelated abstract categories. This fact has linguistic interest too, for such connections are a prime locus of neutralisation (witness the dense etymological networks among these notions in natural languages).

The dual of a diagram is obtaining by reversing arrows. The dual of a colimit is a limit. Instances of limit and colimit are initial and terminal elements, and pushout and pullback. A pushout of two arrows is an object and two arrows from it that makes a square diagram commute. Again the object is the initial object of the co-cone of such candidates. Examples of pushout are coproduct, sum, join, unification, or domain of a metonymy. A pullback is the dual of a pushout. Examples of pullback are (free or fibred) product, Boolean meet, generalisation, or image of a metaphor.

![Figure 3](image3.png)

A product of objects is an object \(a \times b\) and arrows (projections) \(a \times b\) and \(a \times b\) from the product to the components \(a\) and \(b\). The dual is a coproduct (sum) of a family of objects is an object \(a + b\) and arrows (injections) from the objects to the coproduct.

Examples of products are event type as product of type, participants, time and place, and refinement of a Boolean algebra. Examples of coproducts are Boolean sum (disjoint join) and quotient of a Boolean algebra.
A product can have a right adjoint (one sided inverse) $a \leftarrow b$ so that $a \leftarrow (b \times c) = (a \leftarrow b) \leftarrow c$. There is an adjunction or Galois connection between arrow and product:

$$a \times b \leq c \text{ if and only if } a \leq b \to c$$

Product is co-adjoint (right adjoint) of the arrow. Instances of adjointness are product and exponential, Boolean meet and implication, binary comparative relations and choice functions, function arity and currying, and categorial grammar. The carrier or forgetful functor of a Boolean algebra which returns the sum of its atoms is adjoint to the functor which maps atoms to the free Boolean algebra generated by them. There is also an adjunction between the product and its projections so that $a \times b \leq a \times 1$ if $a \leq a \times 1$.

Turning the diamond diagram forty five degrees gives a Klein four group.

A category is a quotient category if there is a morphism from the quotient to the numerator which is bijective on objects and surjective on arrows. A quotient coarsens the category without losing its arrows, it just takes out the slack from the objects. That can happen when there is slack, i.e. the bigger category is not propped full of arrows (enough to distinguish its objects). For instance, in model theory, there is slack due to logical equivalence. The quotient, or Lindenbaum lemma, removes it by mapping synonyms to synsets. The dual of a quotient is called residual. It is a refinement of a category by another category.

A functor is an arrow (morphism) between categories which maps objects to objects and morphisms to morphisms. A functor is contravariant if it reverses arrows and contravariant if it does not. Two contravariant functors compose to a covariant one. An example of contravariance is logical type shift one level up. Two shifts are covariant. What is a product is a coproduct at the next level up or down.

Examples of covariance are logical type shift two storeys up or the Stone duality of Boolean algebras and discrete topological spaces.

For instance, any partition, like a classification of objects into big and small, is a coproduct. A function from context sets to such partitions is a choice function, whose adjunct is the revealed a binary preference relation.

The category theoretic concept of product can be used to explicate the duality of word order and morphology in natural language. A product, consisting of an object $ab$ and projections $f: ab \to a$ and $g: ab \to b$, can be equivalently represented as an indexed product $(a,f)(b,g) = (b,g)(a,f)$. This product is commutative, for the projections are now carried along with the terms of the product.

Alternatively, a product $ab$ can be represented as the product of the left and right projections paired with identity on the right or left respectively: $ab = (a,1)(1,b) = (1,b)(a,1)$ This product is again commutative, for componentwise multiplication gives back $(a1)(1b) = (1a)(b1) = ab$ on either order. (Compare also section on linear algebra.)

A natural transformation is a morphism of functors. Categories connected by invertible natural transformations are equivalent. For instance, adjoint categories, like sets and free Boolean algebras on them are equivalent. Meaning preserving type shift in natural language semantics (the category theorist’s “is” is natural equivalence.

A language like feature of category theory is that it does not count. Categories which only differ numerically are equivalent, and represented by their quotient under equivalence, or skeletal category.

The strength of the category theoretic perspective is that it gives precise meaning to the analytic-synthetic duality, explicating general analytic concepts such as quotient, partition, disjoint union,
factoring out, finding the common denominator, going to equivalence class, generalisation, abstraction, or schematic meaning (all instances of finding colimits) and synthetic concepts such as product, factorisation, fixing dimensions or coordinates, (de)composition (instances of limits). One side puts together what the other takes apart. For instance, we may represent events as combinations of properties and time, and then project those components, and combine them back. It allows doing language specification piecewise and then combining the pieces together.

In the section on linear algebra, I win will be represented as the meet I|win of the event types where I am the subject with those event types where someone wins. At the same time I win “is” also the relation composition of I\*win of I and win, and the concatenation I.win of the event types I and win. These are all interrelated perspectives on the same event, and all instances of category theoretic product.

Category theory relevant for event structures includes cartesian closed categories and monoidal categories.

**Free and fibred product**

A fibred product or pullback \( \text{ex}_x f \) is a product subject to a constraint or law \( x \) (Barr/Wells 2002). In other words, maps \( d \rightarrow e, d \rightarrow f \) that agree on \( x \) correspond one to one to maps \( d \rightarrow x \). The pairs in fibre product are mapped to a shared third object \( x \). For instance, the composition of two relations contains those pairs in their product which share the middle member. Any binary relation can be thought of as a fibred product (cartesian product subject to a law).

Different notions of product can be ordered on a scale according to the strength of the law constraining them.

- cartesian product, concatenation composition meet identity

Free products satisfy cancellation, composition and meet do not. The last two are commutative (rings with idempotency \( < 2 \)).

\[ ef = \emptyset \text{ iff } e = \emptyset \text{ or } f = \emptyset \]

Free products commute with Booleans, composition does not (it commutes with join and meet but not with complement).

The failure cancellation indicates presence of constraint (a fibred product). Here are some linguistic instances of this.

Plural symmetric (reciprocal) predicates: A and B are unmarried entails A is unmarried, but A and B are not married does not entail A is not married. Only mutual marriage is excluded.

Motion: The composition of two paths from x by y to z entails from x to z, but the negation of the latter does not entail the negation of either component, for there may be alternative paths.

Causality: A causation event kick upstairs entails the sequence of events kick.upstairs, i.e. someone kicks something and something goes upstairs. The negation of the former does not entail the negation of either component, for there are further subevents linking them: the shared object, and the causal connection.

**Chu spaces**

A Chu space (Pratt 1999) is a map from a product of a category and its dual to a third category of (truth) values. The two dimensions can represent any duality: types versus tokens: objects versus properties, objects versus places, times versus events, for instance. Pratt (1997, 1999, …) shows that the construct can be tweaked to represent most all and sundry mathematical objects.

The interest of Chu spaces here is that they match the natural language articulation of what there by an extensional to intensional dimension of objects against an intensional type dimension of concepts. The token dimension is type lower than the type dimension, applies Booleans in extension (join is more) and constitutes the subject of an event. The type dimension is one type higher than the object dimension, applies Booleans in intension (meet is more), and constitutes the predicate of an event. In category

---

23 Suppose \( e \) and \( f \) are objects and \( g \) and \( h \) are maps. A fibred product of \( e \) and \( f \) over \( x \) is an object \( y \) along with morphisms \( p: y \rightarrow e \) and \( q: y \rightarrow f \) such that \( y \rightarrow e \rightarrow x = y \rightarrow g \rightarrow x \), and for any maps \( a: d \rightarrow e, b: d \rightarrow f \) such that \( g^a = h^b \) (i.e. the two maps \( d \rightarrow x \) are the same), there is a unique map \( c: d \rightarrow x \) such that \( a = p^c \) and \( b = q^c \), and vice versa.
theoretic terms, the basic operator of forming events is not a join of tokens or a meet of types, but an
adjunction of a token and a type.

The initial object of the category of Chu spaces is a map from a fourfield of two tokens against two
types to 2, exemplifying polynomial (x vs. x^2) and exponential (x vs. 2^x) duality in one diagram. This
Chu space already makes sense of identity x = y as the meet of two types on one token, as well as sharing
of one type by two tokens. Aristotle’s square of opposites, the Klein four group, and the
commutative square diagram of category theory are two-by-two distinctions, like the four corners of
the initial object of the category of Chu spaces. If one of the dimensions is contracted to a point, a two
way duality of opposites remains.

Points in the Chu space are values of some sort. In the above figure, they are event tokens. Each one is
a product of an event type and a time. Going by rows or columns give two dual one-dimensional
spaces: one maps times to events (the usual view), the other maps events to time (the dual view). The
dual view is what physics calls phase space. A given time is described by the spectrum of events
happening then. Dually, a given event is described by the spectrum of times it occurs in. By the
superposition principle, an (aperiodic) event as the (infinite) sum of (periodic) events, or vice versa.

Cartesian closed categories

Cartesian closed categories are a category theoretic abstraction of the adjointness of product, quotient
and exponent. Any category is a monoid of arrows (morphisms) under composition. In cartesian
closed categories there is a product a × b which has a right adjoint (inverse) ⊣ for every object so
that an adjunction (Galois connection) holds between arrow and product:

\[ a \times b \leq c \iff a \leq b \rightsquigarrow c. \]

Boolean algebras are cartesian closed. Lambda calculus, combinatory logic and categorial grammar are
other well known instances of c. c. c. A Heyting algebra is a cartesian closed and finitely co-complete,
but not complete. (Cf. section on priority Booleans.) Relation algebra composition is a tensor product
distinct from its cartesian product (Pratt 1997).

Categorial grammar

Categorial vagueness or polymorphism of natural language is studied in categorial grammar (Lambek
a fixed logical type, to define a calculus which allows unmarked shifts between categories. Unmarked
aspect shifts and coercion in Moens (1988) are an instance of this idea.

Categorial grammar can be thought of as the grammar of type theory. Categorial grammar builds
sentences using type inference on type assignments for their parts. Different versions of categorial
grammar buy into different subsets of the types and rules of inference valid for classical logic. A
categorial grammar hierarchy has been laid out in van Benthem (1991:247, 1996:252). Each richer
system includes the earlier ones. Each adds a structural rule of inference characteristic of a given
combinator.

<table>
<thead>
<tr>
<th>Adjukiewicz calculus</th>
<th>application, cut, modus ponens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambek calculus</td>
<td>composition, conditionalisation, lifting</td>
</tr>
<tr>
<td>Linear logic</td>
<td>commutativity, permutation</td>
</tr>
<tr>
<td>Relevant logic</td>
<td>cancellation, contraction, idempotence</td>
</tr>
<tr>
<td>Intuitionistic logic</td>
<td>monotonicity, expansion</td>
</tr>
<tr>
<td>Classical logic</td>
<td>Peirce’s law ((a → b) → a) → a</td>
</tr>
</tbody>
</table>

Lambek calculus is sound and complete with respect to relation algebra by the following
correspondence (van Benthem 1996).

<table>
<thead>
<tr>
<th>Lambek type</th>
<th>relation algebra operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ab</td>
<td>relation composition</td>
</tr>
<tr>
<td>a\b</td>
<td>left residual (relation inverse)</td>
</tr>
</tbody>
</table>

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24 This is the characteristic axiom of Lambek calculus, Kandulski (200?)

25 The application grammar of Shaumjan and Soboleva (1965, 1971) lays out a typed categorial
grammar, a set of basic types for function words and morphological affixes, plus a transformational
calculus of some sort for type inference.
Dynamic logic

Dynamic logic (Segerberg 19??, Pratt 19??, van Benthem 1991, 1996) combines unary Boolean algebra and binary relation algebra into a two-sorted system. Modal logic style, the first implicit argument is a state index. The characteristic operations map between states and actions, which are binary relations between states. In relational algebra, dynamic logic weak modality $\langle e \Rightarrow r \rangle e$ can produce $r$ is representable as $s \langle \exists f \langle \bar{e} \rangle \rangle s$. This should be compared to the counterfactual definition of $e \ 	ext{let} \ r$ as $s \cap s \langle \exists f \langle \bar{e} \rangle \rangle s$. The dual of enablement, necessitation $e \langle r \rangle e$ will produce $r$ will then correspond to $e \ 	ext{cause} r$. The operators $?p$ for ‘test $p$’ and $p$ for ‘ensure $p$’ map from states back to actions. The former is definable using priority operators as $?p \langle \bar{e} \rangle$ and the latter as $\langle p \rangle$, corresponding to a precondition-free variant of $\text{become}$. The dynamic logic primitives thus provide an alternative choice of primitives for the $\text{cause-become}$ fragment of the present calculus. The program constructs $\text{if then else}$ and while do or repeat until are definable in a similar fashion.


The event-object duality is realised in computational theories of events as the duality of control flow and data flow. Control flow takes events through a state space, defining alternative courses of events. Data flow takes objects through a network of relations, defining event participant structures. There is a spectrum of systems from single-agent active ones with complex control flow (flowcharts) to multi-agent reactive ones where all the action is in the wiring (Petri nets, neural nets).

The formal analogy between relation algebra and regular events, states corresponding to properties and events to relations, is exploited in dynamic logic (van Benthem 1991, 1996). A finite network of binary relations is formally similar to a finite state automaton. This analogy is exploited in the theory of Kleene algebras over matrices (Kozen 1992, Desharnais 200??).

van Benthem (1996) uses relation algebra to compare various dynamic logics as restricted varieties of classical reasoning. The idea is to restrict valuations (assignments) from a static set (corresponding to the cartesian product, or universal relation, of individual assignments) into a dynamic net which imposes constraints between successive assignments. This is analogous to the move from classical logic to modal or resource bounded logics.26

Ontology

Untyped Boolean combinatorial logic is inconsistent (Curry/Feys 1958). Combinatorial logic or lambda calculus operates on reflexive domains (Scott 1973), countable cartesian closed spaces isomorphic to their own function spaces (Soy 1979). They allow expressing recursive arithmetic, closures, and fixpoints. In particular, combinatory logic defines the fixpoint combinator $Y$ which returns for any function $f$ the fixpoint of $f$, i.e. $Yf = Yf$. If implication $\to$ or negation $\neg$ is introduced to the language, their closure or fixpoint is the contradiction $\bot$, and the entire language is derivable. $\emptyset = 1$ becomes true, so duality reduces to triviality.

In category theoretic terms, the category of complete atomic Boolean algebras is not cartesian complete. Conversely, the logic, or topos, of cartesian complete categories is not the two-valued Boolean algebra, but the four-valued intuitionistic Heyting algebra.

The paradox of self-contradiction goes back to the ancient paradox of talking about what is not. Since paradox is deduced from a combination of negation plus reflexion (abstraction), there are (apparently) alternative ways out: restrict negation, restrict reflexion, or restrict deduction. All of them have been explored, leading to constructive logic, set theory, type theory, or nonclassical proof theory among other things. No one winner has emerged. Instead, logic has branched off in different directions.

One option is to just ignore the paradox. This is what natural language does. It blithely generates this sentence is not true and leaves logicians to wonder what to do about it. I shall do the same. I use what I need from Booleans and combinators, leaving foundational worries aside.

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26A corresponding constraining effect on the free algebra of events is also obtained by restricting the universe of event tokens $S$, or by construing events as transducers which are more selective about their arguments than the entirely unconstrained $\text{ex}$. 
**Tokens and types**

Regular operators on simple event tokens can be lifted to complex event tokens and further on to event types in the usual way of formal language theory (Salomaa 1973, van Benthem 1991,1996). In formal language terms, a word is represented by the family of languages containing only the unit language containing it, a language by the family of languages including only it, and a language family by itself. There are two levels of abstraction here, from simple event tokens (strings) to complex event tokens (languages) and from complex event tokens to event types (families of languages).

The domain of actual events is in general not closed under regular operations (not free). Operators can be thought of as restricted by or relativised to an underlying universe $S$ (van Benthem 1991). If $x$ and $y$ are complex event tokens then

$$xy = uv \in S: u \in x \land v \in y$$

and if $e$ and $f$ are event types then

$$ef = xy \in R: x \in e \land y \in f$$

A simple event token is lifted to a complex event token by considering its unit set. A complex event token is lifted to an event type by considering its unit set. After these identifications, we can let all variables range over event types, some just more restricted than others, and build up the calculus using primitives of Boolean and regular algebra only, fading out the type-token distinction. The loss of information from identifying a set with its singleton is compensated by viewing events implicitly or explicitly as elements of specific Boolean algebras. Being a member of a set translates to being an atom of a Boolean algebra. A unit set generates a Boolean algebra isomorphic with the trivial Boolean algebra $2$.

In Montagovian terms, simple event tokens (type $e$); complex event tokens ($t/e$) and event types ($t/t/e$) are all lifted to the logical type of properties of complex events ($t/t/e$). The technique is familiar from typed higher order logic. The duality of extension: sets of individuals (type $t/e$) and intension: sets of properties of individuals (type $t/t/e$), is a case of category theoretic contravariance (McLane/Birkhoff 1967). This is the duality of points and their neighborhoods, individuals and properties, situations or propositions and possible worlds, theories and their models, or partial valuations and sets of total valuations (Barwise and Perry 1983, Benthem 1985:44ff). Arrows are inverted: as intension increases, extension decreases and vice versa. In general, going one step up, operators are inverted. Universal quantifiers translate into existential (in fact, definite) ones one type higher (Benthem and Doets 1983:309).

Similar constructions are possible in the domain of objects; allowing analogous talk of object tokens and object types.

Two inversions cancel one another, so that there is a covariant mapping between individuals (type $x$) and first order quantifiers (type $2^x$). It is exemplified by the Stone representation theorem saying that the second dual of any Boolean algebra is isomorphic to it (Halmos 1974:78). Thus types can be isomorphically lifted two stories up, as is done in Montague grammar or Boolean semantics (van Benthem 1986:67, Keenan/Faltz 1985). Individuals map by Leibniz law (an individual is the set of its properties) to Boolean homomorphisms, or principal filters in the algebra of first order quantifiers. The following diagram describes the situation:

This diagram can be related to the observation that natural language types do not go beyond third order.

![Diagram](image-url)
van Benthem (1986:65). The first two types appear in a subject-predicate event type, the third is obtained by subject-predicate inversion. A second inversion gets us back to where we started from. It does not make sense to ask what the logical type of a natural language expression is. However, and expression may have a lowest type in which its logic can be captured. For uniformity (conjunctive instead of disjunctive definition), one climbs up the ladder to where all expressions become special cases of the same type.

**Type shifts**

I shall not develop a separate type theory as a metatheory to a concrete syntax. Instead, the entire calculus is built from types: event types, object types, property types, relation types, et cetera. Everything is types, from tokens to logical constants. The highest types may well be dubbed logical (those closed under permutations, or automorphisms, as suggested by van Benthem). Between logical types and concrete tokens there is a full spectrum of intermediates. I allow that types of natural language expressions are not fixed, but may shift along various natural transformations between categories with or without explicit warning.

The theory assumes a liberal supply of combinators or type shifting operators between categories. In fact, such operators are the main object of study here. Under my catholic notion of type and type shift, I subsume types and combinators described in functional type theories like lambda calculus, combinatory logic or Lambek calculus, but also shifts between functional and relational types, Boolean types, even shifts through category theoretic morphisms and equivalences. Perhaps it is right to say that my types and type shifts are objects and morphisms. In particular, I don’t bank on the (e,t) regime of Montague grammar (van Benthem 1986:65, Keenan/Faltz 1985).

I shall denote types by typed variables and operators on them. I won’t stick to any one notation, but vary notations as seems fit. Aspect types denoted by a, b, c, … are subtypes of type e of events. Untyped bindable variables x, y … range over all types. Concatenation of event types produce more event types, as do other operators. Functional event types can be produced with the abstraction operator. For instance, the characteristic function of an event type e is \( x:e \cap x \). which denotes 1 if \( e > \emptyset \) else \( \emptyset \). (This will used to produce a truth definition below.)

Types may exemplify a variety of different categories. Among them is Boolean algebra, which allows defining notions of subtype and compatible type, among other things.

The type of one-place events px is a product of one-place event types p = p:px and objects x = x:px. Under an appropriate type shift, for instance the projection p = x:px which identifies an event type with its participants, px is equivalent to the meet p \( \cap \) x. (Equivalent in a category theoretic sense, viz. related by a reversible natural transformation.)

There are similar shifts among different representations of two-place event types xry. A binary relation maps to the one-place subject-predicate event type by subject abstraction \( x:r y \). Different word orders are produced by the right combinators, for instance \( r y = \text{Cl} x y \). Free word order with dependent marking can be represented by a type shift which replaces composition with meet:

\[
\text{xry} = x_\cap \cdot r_\cap \cdot y
\]

Here the roles of \( x \) and \( y \) in the event type are marked on the arguments by cases. Head marking can be represented as argument abstraction

\[
\text{xry} = (x:y:r) \cdot x \cdot y = x_\cdot (y_\cdot r_\cdot y) \cdot x
\]

where the roles of \( x \) and \( y \) are marked on the head.

In sum, I give up trying to stick to a single underlying logical form. Generalising the idea of Lambek calculus, I allow unmarked type shift, or type inference, happen dynamically during the process of interpretation. Any shift of language model will do which makes sense of the grammar and semantics of a given expression. It need not be the same language model for all constructions, nor need it be unique within even one construction, as long as types can be systematically mapped to others. This is the spirit of category theory. To quote one mathematical physicist:

If you find this confusing, take heart. Getting confused this way is crucial to learning n-category theory! After all, n-category theory is all about how every “process” is also a “thing” which can undergo higher-level “processes”. Complex, interesting structures emerge from very simple ones by the interplay of these different levels. It takes work to mentally hop up and down these levels, and to weather the inevitable “level slips” one makes when one screws
up. If you expect it to be easy and are annoyed when you mess up, you will hate this subject. When approached in the right spirit, it is very fun; it teaches one a special sort of agility.

John Baez, *This week’s finds in mathematical physics* 75, http://…

**Object-event duality**

Quine (1960, 1985) is an ontology where objects and events are basically the same kind of (filled) four-dimensional regions of spacetime: objects are stable events and events unstable objects. Weather words like rain straddle the distinction. *Pace* Quine, we don’t normally think of events as individuals on a par with you and me, with temporal continuity and spatial boundaries, but rather as *types* classifying situations, occasions, or times where events take place (Eckardt 1997, Bennett 1988:§42). I return to this topic in the section on locative cases.

Differences between events and objects have been pointed out in literature. Objects exist in their entirety from the time they first appear, events (well, closed complex ones) only when they are all there (Schmitt 1983). In this respect, objects are like states. Objects, like states, exist at moments. There has been related controversy about whether events can move about in space (Dretske 1967) or objects in time (Kripke 19??). Cooper (1986) suggests (some) states have no location (e.g. love), but cf. Link (1998:306).

Bennett (1988, Zucchi 1993, Link 1998) makes a distinction between events as facts and events as individuals. *Brutus killing Caesar* is a fact, *The murder of Caesar* is an individual event. A fact carries its identity criteria on its sleeve: any two nonequivalent descriptions of fact describe different facts. *Caesar dying* is a different fact from *Brutus killing Caesar*. An individual event has parts and it can be described in different ways: *The murder of Caesar and Caesar’s death* (can) refer to the same event. I see this distinction as one between event type and event token. The event type *Brutus killing Caesar* does not fix any particular way for Brutus to commit the act. The factual complex event token *Caesar’s death* contained many other event tokens, including a murderous stab by Brutus. The type extreme is Kim’s fact metaphysics of events, the token extreme Quine’s space-time region metaphysics, with Link (1998) taking an Aristotelian midway position. I go with Bennett who says that event identity talk covers the whole spread (Bennett 1988:§49).

Events and objects are in fact dual. An object can be characterised by the events it participates in. An event can be characterised by the objects that participate in it. This standpoint gets formal support from computer science, where duality of data flow diagrams (which describe the wiring of a network, or the topology of objects) and control flow diagrams (which describe the flow of control, or the topology of events (Stefanescu 19??) is well established.

A category theoretic viewpoint may help here. An event can be viewed as a product of various dimensions; dually, a product space can be constructed from equivalence relations between events in Russellian fashion. Choose a set of dimensions, say, event type, participants, time and place and construe events as products of the dimensions:

\[
\text{event} \subseteq \text{type} \times \text{participants} \times \text{time} \times \text{place}
\]

By taking a suitable projection of the product, keeping some of the dimensions constant and currying some, the set of events can be viewed as a characteristic function of any combination of the dimensions, and each event retrieved as a set of sets in that domain. For instance, an object can be viewed as the set of all events in its life, or as a Quinean four (or more) dimensional world line. Or an event can be construed as a function from individuals and their properties to spatiotemporal locations. This is pure category theory.

Given the degrees of freedom in this game (van Benthem 1986), nothing deep can be associated to the choice of ontological primitives. Rather, natural language semantics should allow alternative perspectives to coexist and shift freely (van Benthem 1986:§3,§7).

**Situation-event duality**

The extensional Boolean algebra of complex event or object tokens can be lifted in a covariant fashion to extensional Boolean operators between event or object types, in the manner of situation schemata in situation semantics (Barwise and Perry 1983:91, van Benthem 1996:§3). Token join \(\bigcup\) is lifted one level up by the definition

\[
e \bigcup f \leftrightarrow \{x \bigcup y \in R : x \in e \land y \in f\}.
\]
Token join has been called non-Boolean conjunction (Hoeksema 1988, Krifka 1989, van Benthem (1991:64.90). It is Boolean all right, being the extensional dual of intensional (propositional) conjunction. For instance, a token of work at night is a join of tokens of work and night (the events just happen together). Walk to work is a token join of walk and go to work, for the two form one event (one causes the other). Jack fell down and broke his crown is the token join of fall and break. Similarly, an extensional relation of involvement e $\subseteq$ f between event types is defined by e[f] = f. For instance, kissing f involves touching e because every kiss is a touch.

On the extensional view, walk and chew gum cannot be the meet of walk and chew gum, because as spatiotemporal individuals, walking events and chewing gum events are separate, have no common members.

The contravariant, intensional approach to lifting event tokens to types defines Booleans that are dual to the extensional ones. In the intensional perspective, a complex event is a situation or location at which different types of events occur contiguously, and an event type as a set of such situations. This intensional sense is the one apparently intended in Galton’s (1984:55) definition of subevent:

An event (type) $E^\prime$ is a subevent of an event (type) $E$ if every occurrence of $E^\prime$ is also an occurrence of $E$.

I propose to call Galton’s subevent relation type inclusion or subtype relation $\subseteq$ and the related Booleans type join $\cup$ and type meet $\cap$. For instance, carry a suitcase in the right hand is type included in carry, and carry a suitcase in each hand is the type meet of carry a suitcase in the right hand and carry a suitcase in the left hand. The token join $\cup$ of event types corresponds to type meet $\cap$ in that both constitute a further specification of an event type. Saying extensionally that kissing involves touching touch $\subseteq$ kiss equals saying intensionally that kissing is touching kiss $\subseteq$ touch. Token join and type meet are dual: the former is an extensional (mereological) operation, the latter an intensional (inferential) one.

For a concrete example, enumerate individual walks and chewings as $w_1, w_2, \ldots, c_1, c_2, \ldots$. Then the extensional event type (only/all) walk would be a set of form $\{[w_1], [w_2], [w_1, w_2], \ldots\}$, or the set of complex events including only walks, and similarly for chewings. The token join of only walk and only chew contains complex events of walking and chewing, while their meet is empty.

The corresponding intensional event type (also/some) walk would be a set of form $\{[w_1], [w_2], [w_1, w_2], \ldots\}$ consisting of all complex events which include some walk, and similarly for chewing. These event types are in effect situation types, so walk is the type of walking situations and chew gum is the type of chewing gum situations, whose intersection walk $\cap$ chew gum is the type of walking while chewing gum situations. I.e. we have some walk = $\{x \in R: w \subseteq x$ and $w \subseteq$ all walk $\}$. Both of the dual viewpoints appear in our thinking about events (Galton 1984, Zucchi 1993, Link 1998).

This duality seems in fact to distinguish nominal and verbal individuation, or objects and events (Boole 1858: 176, Bennett 1988:18fn10). As tokens, events and objects “are” both Quinean space-time regions. But we tend to treat objects as tokens, events, properties and relations as types. From a Boolean point of view, identifying events by situations and identifying them by individuals participating in them do essentially the same work, i.e. shift from viewing events as individuals to a dual view of them as types or properties.27

For a finite model for the calculus, construe a printed page (like this one) as an event universe. Character tokens stand for event tokens, lines stand for sequences of event tokens. Sets of columns of the page represent times and paragraphs count as complex event tokens. Strings of character $c$ represent tokens of the state $c$. Event type $e$ is dually represented by the set of paragraphs which include tokens of $e$. The type meet $e[f]$ is the set of those paragraphs which include tokens of $e$ and $f$. The token ideal of $c$ is equal to $c$, because strings of $c$ only include other strings of $c$. Tokens of event type lowercase include tokens of all lowercase event types.

State-event duality

There is a school of thought which construes the distinction between states (or open event types) and events (or closed event types) as a sortal one (Pratt 1979, Partee 1984, Galton 1984, Löbner 1988, Herweg 1991, Pratt 1992).28 Formally, states are properties of times and formalised as monadic first

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27 It is probably reflected in the solution of Stoic philosophers to treat nouns extensionally, as bodies, and verbs intensionally, as linguistic entities (Luhtala 1997).

28 A sorted logic is equivalent to an unsorted one with one-place predicates to name the sorts.
order predicates on times, while event tokens are first order quantifiable individuals. Thus *It was raining* translates as \( \text{rain}(t) \) \& \( t < \text{now} \) and *There was a flash of lightning* as \( (Ee)\text{flash}(e) \) \& \( t(e) < \text{now} \). States as predicates of time represent arbitrary sets of time without quantifying over them. Events as quantifiable individuals are discrete. They are related to but not identified with the times they hold of, which is another way to avoid quantification over sets of times.

This idea has seemed particularly attractive to writers who start out from first order quantification theory and/or Priorian tense logic. First order logic is essentially the logic of finite number and discrete individuals. More precisely, it is unable to distinguish finite from infinite and discrete from continuous. First order predicates are not individuated (there is no quantification or identity for predicates), individuals are. As long as one sticks to first order logic, there is no other obvious way to make the count-noncount and discrete-continuous distinctions than a two sorted approach. People who feel events are categorically different from states usually contrast changes to simple states. Lombard (1986) actually says all events are changes. Those who feel events and states are the same sort of thing don’t make this simplification (Brod 1923, Davidson 1980, Bennett 1988).

Galton (1984:27-28) summarizes the differences: a state is homogeneous, disjunctive (has the subinterval property), and negatable, and obtains or fails to obtain from moment to moment; an event, on the other hand, is inhomogeneous and unitary (has the non-subinterval property), and occurs a definite number of times (possibly not at all) within a period of time.

A claim for a sortal difference is a generic statement, one which is not true or false simpliciter but useful or not. Let us consider some of the arguments. One argument by Löbner (1988:166) is that states are closed under complementation, events are not. True in a sense: the pointwise complement of a state is also a state, while complement in general does not preserve event type. Another argument Löbner (1988:168) is that an event analysis would not work for a state *Es war kalt*. An analysis “es gibt ein Ereignis e von der Art ‘es ist kalt’, das vor dem Sprechereignis stattfand” would wrongly imply that the state holds no longer. as “ein Ereignis dieser Art könnte nur das Auftreten einer geschlossenen Kältephase vor dem Sprechereignis sein”. This argument begs the question, as it identifies event with closed event.


Herweg’s thesis is that each approach can only properly treat its native side of the aspect opposition. The constructive aspects of the paper will be discussed later. Some of the impossibility claims can be examined here.

Herweg feels a propositional approach cannot account for the present tense in performative statements, because ‘an interval does not become the truth interval for an event-type proposition until the event has come to an end’. I suspect this is a residual intuition from thinking in terms of truth at points.

One objection against time as the primitive is that time is not enough to individuate events: one can break an arm at once in two different places. The example does show that at least time and space are needed to distinguish concrete events from one another. (In this respect, concrete events are no different from concrete objects.) Eckardt (1997) argues that time and space do not suffice either (say, one can insult twice in one sentence).

Herweg allows that ‘rather sophisticated provisions using possible worlds’ might suffice to individuate events. There is nothing particularly sophisticated about possible worlds, situations, or indexes, they are just extensional duals of intensional event types. The main attraction of event types over situations that there appear to be less of the former when there is only partial information available. Situations (Barwise/Perry 1983) or model sets (Hintikka 1969) combine features of both approaches.

Herweg’s objection against an event based treatment of states is predicated on his assumption that an event semantics must provide a discrete criterion of individuation which makes events atomic and countable. He goes on to say that for states there are two atomic individuation criteria, fixed duration \( s\cap t \) and maximal convex subset (cycle) \( \sim s \sim s. \) Of these only the latter one produces a countable set of events.\(^{29}\)

Herweg’s argument that a medial episode of a state and a maximal one cannot belong to the same event type equivocates between \( \sim s \sim s \) and \( s \sim s' \sim s \) (closure and interior). The interior of a cycle \( s \sim s' \sim s \) is at

\(^{29}\) Basic situations in Bartsch (1995:130) are such event-type-maximal events.
the same time atomic in its native event type and a member of the event type s. The rest of the argument tries to show that an event semantics for states (DRT, Bäuerle 1988) succeeds only if the countability requirement on events is rejected. (I reject it).

Herweg goes over a number of other familiar Aristotelian contrasts between states and events. Following Dalton (1984) Herweg does not distinguish between states and processes. For him states are homogeneous: if a state holds over some period of time it also holds at each part of this period while events are heterogeneous: no proper part of the overall time occupied by an event is also a time at which the event occurs (Frege 1884:66). According to Herweg, it is exactly this property of homogeneity which durative (measure) adverbials require, and it is the reason why states cannot be counted.

Citing Krifka (1987,1989), Herweg points out characteristic persistence properties of states and events: states and durative adverbials are downward persistent, location adverbials are upward persistent. Here again one has to proceed more cautiously. States are downward entailing, activities are only almost so (up to atoms). Durational adverbials are downward entailing to a resolution, but not arbitrarily: breathing, walking, or working for a while does not entail breathing, walking, or working for every minute of the while. In fact, it is not even sure that one has to breathe for any minute of it. When the scale is brought down to a minute, there may be no cover in seconds of sustained breathing left to be found.

Another qualification is in order concerning Herweg’s formulation of the anti-subinterval property: if an interval is a truth interval of an event-type proposition, no proper subinterval of it is also a truth interval. The anti-subinterval property entails an event is atomic. I have argued the subinterval property characterises states but not activities. The characteristic property of all open events is not the subinterval property, but upward closure under join. Its contrary is an anti-additive property: the join of two events is not in the same event type. I think this is the relevant property for closed events, not the anti-subinterval property. The difference is that the anti-additive property is not only satisfied by atoms, but also by arbitrary nests of events of the same type. The two definitions coincide for Boolean algebras, but the denotation of a closed event is not a Boolean algebra. I have argued that closed events are vague about their boundaries, so around a change of state, there is a nest of changes of the same type converging to the ultimate point of change. This is allowed by the anti-additive property. Recalling my earlier comment on counting waves, it is possible to count vague events by counting the culminations, even if the boundaries are vague. This shows that the anti-additive property is also sufficient for counting.

Galton’s (1987) model theoretic semantics for his two-sorted system makes states denote sets of points of time while events denote pairs of states (the initial and final states of the events). Aspects are defined in terms of the states: the perfect denotes the final state, near future the initial state, and the progressive the complement of their union. All this agrees with my developments. So does Herweg’s formalism, for all its sortal philosophy.

Instead of claiming a sortal distinction, it seems better to bank on the interdefinabilities between the two sorts. (cf. Verkuyl 1993:242, Bennett 1988,1996 Parsons 1990). There are differences between states and events, but there are obvious interconnections as well. In many sortal approaches, notably dynamic logic, there are aspect operators which take events to states and back (Löhner 1988:180, van Bentham 1996). My conclusion is the opposite from Herwegs: not only are the state and event perspectives compatible, they are dual and interchangeable. One can construct states from events or events from time, either way (van Bentham 1982, Landman 1992). Duality is at work here, making the state and event world views intertranslatable.

Thus van Bentham (1996) maps the duality of states and events as one between monadic Boolean algebra for state and dyadic relational algebra for events, with projections taking one from procedures to statements and dynamic logic style modes (generate, test) from statements to procedures. Changes

---

30 Herweg 1991b defines homogeneity as the combination of downward distributivity and upward cumulativity.
31 There is no need, in fact no way, to formulate a separate downward closure condition for activities (Carlson 1981). What holds true already follows from the upward condition, while the putative downward condition (e.g. Smith 1991:45) is just vacuous.
32 The closure conditions covary with the type-token distinction. The level at which they cease to apply defines tokens of a type. Some abstract count nouns appear additive and closed under parts, such as set or time. The union of two sets is always a set (type), but not the same set (token). Time has both count and noncount uses. A particular time is atomic in the same sense as events, since no part of it is that same time (Herweg 1991).
correspond to relations between states, and states correspond to identity relations. This my construal of change as well.

A further reason not to make the state-event duality an absolute one is that it repeats itself on higher levels of abstraction. A state of change (a change whose derivative is constant) is a state relative to change of change (a change whose derivative is a simpler change). Similarly, oscillation around a point is a state on a coarser resolution, but a change relative to a finer one.

Finally, states and changes can be dually mapped on to one another: a state is what connects two changes just as a change connects two states. This is the geometrical duality of points and lines, or graph theoretic duality of vertices and edges, or the categorial duality of objects and arrows.

**Type shifts**

Duality ambiguities between Booleans arise depending on which step of the type hierarchy the operators apply, even or odd (Keenan/Faltz 1984:270): It explains why natural language and seems to equivocate between token join and type meet (Keenan/Moss 1985, Westerståhl 1989:57, van Benthem 1991).

<table>
<thead>
<tr>
<th>all officers and gentlemen</th>
<th>( \bigcup (\text{officers } \cap \text{gentlemen}) )</th>
<th>( \bigcup (\text{officers } \cup \text{gentlemen}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>all officers or gentlemen</td>
<td>( \bigcup (\text{officers } \cup \text{gentlemen}) )</td>
<td>( \bigcup (\text{officers } \cup \text{gentlemen}) )</td>
</tr>
</tbody>
</table>

Similar things happen with questions about time. Consider the following questions and answers:

<table>
<thead>
<tr>
<th>When did Socrates live?</th>
<th>( \bigcup s )</th>
<th>From 469 to 399 BC.</th>
<th>469( \leq )399</th>
</tr>
</thead>
<tbody>
<tr>
<td>When did Plato live?</td>
<td>( \bigcup p )</td>
<td>From 427 to 347 BC.</td>
<td>427( \leq )347</td>
</tr>
<tr>
<td>When did Aristotle live?</td>
<td>( \bigcup a )</td>
<td>From 384 to 322 BC.</td>
<td>384( \leq )322</td>
</tr>
<tr>
<td>When did Plato and Aristotle live?</td>
<td>( \bigcup (p \cap a) )</td>
<td>From 384 to 347 BC.</td>
<td>384( \leq )347</td>
</tr>
<tr>
<td>When did Plato or Aristotle live?</td>
<td>( \bigcup (p \cup a) )</td>
<td>Between 427 and 322 BC.</td>
<td>427( \leq )322</td>
</tr>
<tr>
<td>When did Socrates and Aristotle live?</td>
<td>( \bigcup (s \cap a) )</td>
<td>Never.</td>
<td>( \emptyset )</td>
</tr>
<tr>
<td>When did Socrates or Aristotle live?</td>
<td>( \bigcup (s \cup a) )</td>
<td>Between 469 and 322 BC.</td>
<td>469( \leq )322</td>
</tr>
</tbody>
</table>

**Table 3**

*Socrates lives* \( s \) is a state, an ideal of events. Its join \( \bigcup s \) is the *life of Socrates*. *Plato and Aristotle live* is the meet \( p \cap a \) of *Plato lives* \( p \) and *Aristotle lives* \( a \), whose join \( \bigcup (p \cap a) \) is the maximal event of Plato and Aristotle both alive. The event type of Plato or Aristotle alive is \( p \cup a \), which has disconnected members. Its join \( \bigcup (p \cup a) \), the whole span of Plato and Aristotle alive, is connected and equal to \( \bigcup p \cup \bigcup a \), the join of their lives. The event type *Socrates and Aristotle live* \( s \cap a \) is empty, and the event type *Socrates or Aristotle lives* \( \bigcup (p \cup a) \) is disconnected, for Socrates died before Aristotle was born.

The maximal element of \( s \), the *life of Socrates* \( \bigcup s \) is atomary in its own event type. Consequently, the meet of the entire lives of Socrates and Platon \( \bigcup s \cup \bigcup p \) is empty. By duality, \( \bigcup s \) equals the meet \( \bigcap \neg s \cap \neg s \) of the closed event type \( \neg s \cap \neg s \) *Socrates lives (once)*, which is a filter of events around Socrates’ life. The dual of the state \( s \) *Socrates lives (all the time)* is the filter \( \neg s \cap \neg s \), *Socrates lives some time* The event types \( s \cap a \) and \( a \cap s \) have a nonempty meet \( s \cap a \cap s \cap a \), *Socrates and Aristotle live some time* which occupies any time including moments in the lives of both philosophers. The event type \( \bigcap (s \cap a) \cup (s \cap a) \) or equivalently \( \bigcup (s \cap a) \) is the minimal one spanning the lives of both philosophers from the birth of Socrates to the death of Plato.
The event type \textit{Socrates or Aristotle lives} \textit{s}U\textit{a} is nonempty, open and disconnected. The join of their lives \textit{Us}U\textit{a} is a closed disconnected event type with a gap in between when Socrates was dead and Aristotle not yet born. It holds at the equally disconnected time \textit{469≤399U384≤347}.

These inferences match the variety of answers available for the last two questions above. The first few answers take the question to be \textit{in sensu composito} ‘When was it that Socrates and Aristotle lived? The last answer takes the question \textit{in sensu diviso} ‘When did Socrates live and when Aristotle?’

The contrast between a state and its join (maximal element) will be important in understanding the behavior of time adverbials, which can fit an event either loosely or tightly. An adverbial has tight fit when all of its own time. Therefore, divide time into isomorphic to the quotient algebra \textit{a}B\textit{a} (Chang/Keisler 1971:§5.5). Dually, the relation \textit{a}∧\textit{b} is an equivalence whose equivalence classes form another Boolean algebra \textit{homomorphic with} \textit{a}B\textit{a}. Its equivalence classes form another Boolean algebra \textit{homomorphic with} \textit{a}B\textit{a} (Chang/Keisler 1971:§5.5).

Whether Booleans distribute in an event type depends on their types. For instance, (read\textit{U}write) \textit{∩} \textit{yesterday} is equal to \textit{(read\textit{U}write)} \textit{U} \textit{(write\textit{U}write\textit{yesterday})} only when the Booleans are of the same order. Talking or listening \textit{all yesterday} does not entail talking \textit{all yesterday} or listening \textit{all yesterday}. In the algebra where \textit{for a time} \textit{and talk and listen} are elements of the same type \textit{talk and listen} is not a join of event types. The event type is either

\[(\text{read\textit{U}write}) \textit{∩} \textit{yesterday} = \textit{yesterday}\]

where the Booleans are of the same type and distribution goes through, or its dual

\[(\text{read\textit{U}write}) \textit{∩} \textit{yesterday} = (\text{read\textit{U}write})\]

where the join is one order lower than the meet and does not distribute, the join being an atom in this algebra.

\textbf{Filters and ideals}

A \textit{filter} over an event type \textit{e} is an event type \textit{f} so that

\[
\begin{align*}
\text{e} & \subseteq \text{f} \\
\text{if } g,h \subseteq \text{f} \text{ then } g\cap h & \subseteq \text{f} \\
\text{if } g \subseteq \text{f} \text{ then } g & \subseteq h \subseteq \text{f}
\end{align*}
\]

(Equivalently, if \textit{g} \textit{⊆} \textit{f} then \textit{g}U\textit{h} \textit{⊆} \textit{f}.) Filters are closed under finite meets and inclusion. The smallest filter \textit{f} over \textit{e} that contains \textit{a} is the filter over \textit{e} \textit{generated} by \textit{a}. It is \textit{principal} if \textit{a} = \textit{∩} \textit{f} and \textit{proper} if \textit{∩} \textit{f} \textit{⊈} \textit{∅}. If \textit{A} maximal proper filter over \textit{e} is an \textit{ultrafilter}. It contains precisely one of \textit{g}, ¬\textit{g} for any event type \textit{g}.

An \textit{ideal} is the dual of a filter. A set of all complements of elements of an ideal is a filter and vice versa. An ideal over an event type \textit{e} is an event type \textit{i} so that

\[
\begin{align*}
\text{e} & \subseteq \text{i} \\
\text{if } g,h \subseteq \text{i} \text{ then } g\cap h & \subseteq \text{i} \\
\text{if } g \subseteq \text{i} \text{ then } g & \subseteq h \subseteq \text{i}
\end{align*}
\]

(Equivalently, if \textit{g} \textit{⊆} \textit{i} then \textit{g}∩\textit{h} \textit{⊆} \textit{i}.) Ideals and filters connect rings, partial orders and lattices. Ideals of a ring form a partially ordered set with respect to inclusion and a semilattice with respect to join. An ideal \textit{i} is \textit{principal} if it is the quotient algebra \textit{b}∩\textit{a} of \textit{b} relative to some element \textit{a}, i.e. \textit{a} = \textit{∪i} and proper if \textit{∪i} \textit{⊈} \textit{i}.

Every ideal defines a homomorphism of Boolean algebras. Conversely, the kernel (the inverse image of \textit{∅}) of every Boolean homomorphism is an ideal (Halmos 1974:48). Specifically, the relation of \textit{a}+\textit{b} belonging to \textit{i} (equivalent to \textit{a} and \textit{b} both belonging to \textit{i}) is an equivalence relation (Chang/Keisler 1971:294, Halmos 1974:48). Its equivalence classes form another Boolean algebra homomorphic with \textit{b}. The kernel and zero element is the ideal \textit{i} and the unit is its dual filter \textit{f}. When \textit{i} is principal (generated by some element \textit{a}) then the quotient algebra \textit{b}∩\textit{i} is isomorphic to the quotient algebra \textit{b}∩\textit{a}. (Chang/Keisler 1971:§5.5). Dually, the relation \textit{a}+\textit{b} ∈ \textit{f} is an equivalence whose equivalence classes form a Boolean algebra. When \textit{f} is a principal filter generated by \textit{a}, its quotient algebra \textit{b}∩\textit{f} is isomorphic to the quotient algebra \textit{b}∩\textit{a}.

For instance, divide time into \textit{night} and \textit{day}. Each of them is an ideal of all time and a Boolean algebra of its own time. The times of transition from night and day and back (\textit{morning} and \textit{evening}) are filters.
round the points of change from night to day and back. For a day animal, time is quotiented to daytime, night time mapped to no time \( \emptyset \).

The event type \( \text{in } e = \text{of } e = x : x \leq e \) is the ideal of subevents of event type \( e \). Extend \( \text{in} \) to a two-place operator \( e \text{ in } f \) by defining it as \( e \cap f \). The converse of temporal \( \text{in} \) is \( \text{round} \), the filter of events including \( e \). Event type \( \text{round } e \) equals \( x : e \text{ in } x \) which in turn equals the event type \( \leq e \) ‘whatever event \( e \) is in’, so \( e \text{ in } f \) equals \( f \text{ round } e \). The meet of \( \text{in } e \) and \( \text{round } e \) is the event type of events precisely \( \text{at } e \).

In the temporal dimension, event type \( \text{in } e \) equals \( x : x \leq e \). In the logical dimension, \( \text{of live} \) may include breathe, awake, asleep, eat, run etc (under relevant circumstances \( e \)). Breathing, sleeping, eating, etc. are facts of life.

Another dual of \( \text{in } e \) is event type \( \text{at } e \) of event types overlapping \( e \), defined by \( \lnot \text{in } \lnot e \). \( \text{at } e \) is an improper filter over \( e \). Events \( e \) overlap temporally when \( e \text{ at } f \) is nonempty. \( e \text{ at } t \) equals \( e \). Proper overlap is \( e \text{ at } \emptyset \). The relation of proper overlap is \( e \text{ at } f > \emptyset \) which shows that \( e \text{ at } \emptyset \) is a variant of meet. Thus \( e \text{ at } e \) equals \( \Theta e \cap \Theta \emptyset \) so \( e \text{ at } t \) equals \( e \cap t \) equals \( e \cap t \). The prepositions \( \text{in } \), \( \text{at } \), and \( \text{round } \) are related by \( e = \text{in } e \cap \text{round } e = \bigcup \text{in } e = \bigcap \text{round } e \). (More prepositions in the section on location.)

\[ e \text{ at } t \] where \( e \) is an event and \( t \) a time makes \( e \) simultaneous with \( t \). Event type \( e \text{ at } t \text{ at } f \) where \( t \) is a time and \( e \text{ at } f \) makes events \( e \) and \( f \) simultaneous. Two times \( t = u \) are simultaneous when they are identical.

Some event calculi take overlap as a primitive notion (either as a function or as a relation) instead of adjacency (Russell 1926, Thomason 1979, van Benthem 1985:37ff). Hamblin (1971) has adjacency (‘abutment’) as the primitive relation. Burgess (1981) starts with inclusion and proper precedence. Given the interdefinabilities, it does not matter which relation is taken as basic.

**Resolution as quotient**

\( \text{Atom} \) is the Greek word for individual. In the Boolean framework, the notion of individual appears as that of an atom. Definition of atom: \( a \) and \( b \) are relatively atomary if they are identical or disjoint; This condition reduces the usual fourfield of Boolean relations (same, disjoint, nested, independent) to a two-valued identity. An element of a Boolean algebra \( a \) is an atom in \( BA \) if it is atom relative to all \( b \). Equivalently, an atom is a minimal element of Boolean inclusion.

A key insight obtained from Boolean algebra is that being an atom is a relative notion. For instance, multinational IBM is both here and there, so places and companies are not relative atoms.

Atoms can be created by quotienting a Boolean algebra relative to some element, i.e. intersecting each element of the algebra with it. This move may exclude some elements, mapping them to \( \emptyset \) (better still, to \( \emptyset^* \)) and turn some previously divisible elements into atoms. This compares to taking a projection of event types relative to an alphabet (Naumovich/Clarke 2000).

This happens in generics. For instance, mapping individual lions to a subset of male lions allows a two-valued answer to a question like does a lion have a mane. Mapping visits to the bathroom to \( \emptyset^* \) allows claiming that one worked all day. Lifting the type of the universal quantifier turns it into a higher order atom. Context shift in general involves taking quotients. USA and Iraq may both be bad, but Iraq is worse, so between the two of them, USA is good.

Taking quotients is an instance of defining a Boolean homomorphism: a monotone (continuous, distributive) mapping which preserves Boolean operations and relations, including zero and unity. The part of the domain mapped to zero is known as the kernel of the homomorphism. If the kernel is \( \emptyset \), the mapping is an isomorphism.

A partition is a quotient of a Boolean algebra. A partition is a disjoint union generated by a set of relative atoms which sum up to \( I \). The elements are the atoms of the generated algebra. There is a natural injection from smaller elements to the partition. To extend this mapping into a full homomorphism decisions must be made about elements straddling the partition. Generic concept formation involves such decisions: is a grey horse, or a black and white horse, a white horse or a black horse? If light grey is practically white and dark grey is black, where does medium grey go? If it goes to white, then white is not closed under complement. Neither is black. Thus vagueness is apt to lead to truth value gaps.

A partition which is the quotient of a weak order can be mapped to numbers. This road leads to measurement.
**Logic**

Event types are terms which denote nonfinite events. What does it mean for an event type to be *grammatically finite*? According to one tradition, a finite declarative sentence does not denote anything. When one asserts an event, one is asserting a Boolean identity, not just quoting a Boolean term. By another one, a finite event type denotes its truth value. According to a third one, asserting an event type means inserting a token of it into the maximum event token, the world. (This is the definition of truth in situation semantics and discourse representation theory.)

In my view, the notions are compatible. A finite event type denotes an event *token*, an event related to *here* and *now*. We assert things when we point out event tokens in our environment. In this view, there is no essential difference between pointing out and asserting (the two phrases are synonymous in English, by the way). An event type like *rain here now* again denotes what it is true of: the meet of rain, here, and now.

By means of a truth definition, one can quantify, or measure how true an event type is. The event type *rain here now* is entirely true if the event types *rain* and *here now* single out the same region of n-space separately as well as put together. It is *partly* true if *rain here now* denotes something positive, more than $\emptyset$. As a *generic* assertion, it is mostly true if the type *rain* covers most of the token *here now*.

Equivalently, one can consider quantifiers as measures of truth or alternative truth definitions. The common property is that the measure is *logical*, i.e. invariant under permutation or automorphism of the domain (van Benthem 1986,1991,1996).

Under a tight (maximal) truth definition, *rain here now* is true only if it is entirely true, i.e.

$$\text{true } e = (e = 1)$$

Under a loose (minimal) truth definition, it is true if it is partly true.

$$\text{true } e = (e > \emptyset)$$

These perspectives on truth are interchangeable. Event type *rain $\cap$ here now* is true on the tight truth definition when *rain $\supseteq$ here now* is true on the loose truth definition.

Accordingly, there are two notions of equivalence between event descriptions, same denotation and same truth value. Two event descriptions may be logically equivalent i.e. the truth (e.g. nonemptiness) of one entails that of the other but denotationally not equivalent, i.e. denote different things, for instance, *die (alive $\neg$alive)* and *dead (alive $\neg$alive)*.$^{34}$

Propositional connectives $\land, \lor, \neg$ abbreviate the composition of a truth definition $\text{true}$ (a Boolean morphism to the binary algebra $2$) with Booleans $\cap, \cup, \neg$. Similarly $\leq$ represents $\subseteq$ in $2$.

**Binary quantifiers**

Consider next binary truth definitions/quantifiers or mappings in $2^{AA}$. The smallest Boolean algebra is the binary algebra $2$ consisting of $1$ and $\emptyset$. This is the algebra of two truth values, truth and falsity, which can be identified with the unit event, i.e. the the world, and the empty event, or nothing, respectively.

The Boolean algebra for one event type $a$ is the product algebra $2^a$, or the four-element algebra $4$ of two atoms $1,a,\neg a, \emptyset$. Quotient with $a$, so that $a = 1$ (the entire universe of discourse), reduces the algebra back to $2$.

The algebra $4$ is also the exponential of the smallest Boolean algebra $2$. It defines the four corners of Aristotle’s square of opposites, or the four truth values of the Klein four group. $4$ relates to $2$ as Heyting algebra to Boolean algebra, or *topos* to *logos* in category theory.

The Boolean algebra $4$ matches the four group *all, not all, some, no* of the Aristotelian logic of classes and the propositional logic connectives *if, but not, and, neither-nor.*

---

$^{33}$The grammatical notion is entirely unrelated to the homonymous mathematical concept.

$^{34}$In the special case of regular expressions, any set of regular expression equations can be represented by just one equation, so the consistency of any regular theory of events can be reduced to the question of the nonemptiness of one complex event (Rozenberg and Salomaa 1997:487).
Table 4

<table>
<thead>
<tr>
<th>~a∪b</th>
<th>a∩～b</th>
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<tbody>
<tr>
<td>a∩b</td>
<td>~a∪~b</td>
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The binary *some A are B* is symmetric and equals unary *some are A and B*. Its binary quantifier dual is the asymmetric *All A are B* and not the symmetric *All are A or B*. In this size, the quantifier *most* falls together with *all*.

Boolean algebras are a cartesian closed category with \( \cap \) as product, as \( \cup \) coproduct having quotient — and residual \( \rightarrow \) as respective adjoints. In categorical terms, *Some all are B* and *All are B* are not dual, but adjoint. (Pratt 1997)

The asymmetry of \( A \) and \( B \) is the the token-type, subject-predicate duality of the two dimensions of a Chu space: \( A \) is the domain talked about, \( B \) is what is said about it. Putting it in another way, binary quantification is unary quantification restricted to the domain \( A \). (van Benthem 1986) In game theoretic terms, a game connected with a binary quantifier involves a choice of subgame connected with \( A \) (Carlson/Hintikka 1976).

**Quantifying truth**

A two-valued truth definition (as the ones just described) is a Boolean morphism which sends event types to one or other of the the limits of the category of events \( 1 \) and \( \emptyset \).

A comparative notion of quantifier is obtained by considering generally Boolean morphisms \( h \) under the truth definition

\[
Q_a \text{ iff } h(a \uplus b) \geq h(\neg a)
\]

The Boolean quantifiers are obtained as special cases by setting \( ha = a=1 \) for all, \( a<1 \) for not all, \( a=\emptyset \) for no and \( a>\emptyset \) for some.

Binary quantifiers like *most A are B* are not definable in terms of unary ones in this setting. The truth definition takes the form (Benthem 1986:82)

\[
aQb \text{ iff } h(a \cap b) \geq h(a \uplus b)
\]

Let \( h \) be the identity mapping and \( \geq \) Boolean inclusion. Then the solutions of \( Q \) are the Boolean quantifiers, *all* \( a \cap b = b \geq \emptyset \) and \( a \uplus b = \emptyset \). Proper inclusion gives *Aristotelean some and all* \( a \cap b > \emptyset \) and \( a \uplus b = \emptyset \).

When \( h \) is a bijection (automorphism, permutation), we get the counting quantifiers: \( h \) maps the smaller member of the comparison to a part of the bigger. A set is infinite if a bijection \( h \) maps it to its proper part. There are *more* fractions than integers in terms of Boolean inclusion (\( h \) identity), but *as many* in number (\( h \) bijection).

Given a measure on the space of events, we can construe a truth definition for *rain* as a normalised measure ranging between \( \emptyset \) and \( 1 \) of the region covered by the event type *rain*. Under this definition, the event type is entirely true if its truth value is \( 1 \), partly true if it exceeds \( \emptyset \), and mostly true if it exceeds half. A binary truth definition for *rain here* similarly divides the region covered by the event type *rain* by the region covered by the event token *here*. This way leads to probability.

Quantifying a generic claim amounts to a straight rule of induction. That *swans are white* is mostly true (its truth value exceeds half) means the truth value of *most swans are white* is \( 1 \).

A logic of counterfactual conditionals is obtained when \( h \) is a utility function (van Benthem 1986:87). This view will be detailed further anon.\(^{35}\)

The Boolean relations \( a \leq b \) and \( a=b \) are binary Boolean quantifiers (*all* and *all and only*, respectively). They reduce events to two (unit or empty event), which makes them distinct from the event types \( a \rightarrow b \) and \( a \rightarrow \neg b \). The former can be defined in terms of latter using the unary quantifier \( a=1 \ all \ a. a=b=1 \text{ iff } a\rightarrow b=1 \text{ and } a\leq b=1 \text{ iff } a\rightarrow b=1. \(^{36}\)

\(^{35}\) For instance, *Most women are talkative* is not equivalent to *Most people are men or talkative*.

\(^{36}\) Only \( Q(b \rightarrow a) = \emptyset \), and not only \( Q(b \rightarrow a) = 1 \) are not on \( a \). Only may also mean *exactly (all and only)* defined by \( Q(a \rightarrow b) = 1 \) and \( \emptyset \) otherwise, which is nonmonotonic (but still continuous). Only is syntactically an adverb.
Genericity

Yesterday, considered as a binary Boolean quantifier, leaves *It rained yesterday* vague, ranging from \( \text{rain}\{\text{yesterday}\} > \emptyset \) (it rained some yesterday) to \( \text{rain}\{\text{yesterday}\} = 1 \) (it rained all yesterday), while *It did not rain yesterday* ranges over the complement. The truth conditions of *it rained yesterday* - the conditions under which \( \text{rain}\{\text{yesterday}\} \) is rounded up to 1 - are correspondingly context dependent and subject to negotiation.

This type of range of vagueness between dual extremes not only characteristic of event language. It is an instance of *genericity* which crops up all over in natural language where explicit quantifier words are missing. *Yesterday was rainy or It rains this time of the year* are equally vague.

The binary logic of truth and falsity thus involves a reduction of the four-member Boolean algebra 4 of the square of opposites to the minimal Boolean algebra 2. Classical two-valued logic (precisely one of \( e \mid t \) and \( \neg e \mid t \) is (non)empty), holds just when *some* entails *all*, i.e. when the mapping defines a Boolean homomorphism of predicates, in effect a singular term (Löbner 1990:16-17, van Benthem 1991:141).

There are three (nonexclusive) situations where this happens. (i) One is when the reference time \( t \) is an equivalence class of coextensive events covering *all* of \( t \). For instance:

> It rained all day yesterday.

Then just one of the contraries *rain* and \( \neg \text{rain} \) has a nonempty meet with \( t \). (ii) Another situation is when \( t \) has indiscrete (atomic) granularity: all but an atomic subevent of \( t \) remains under erasure of irrelevant events.

> The boss was (not) satisfied with your work yesterday.

The relevant occasion \( t \) might be at the end of the day when the boss comes to inspect day’s work. Effectively, the event type has the form \( \text{satified}\{\text{yesterday}\} \mid t \) for a suppressed atomic \( t \). (iii) A third case is when the event type \( e \) is upward monotone (existential). Then \( e \mid \text{yesterday} \mid t \) nonempty already entails \( e \mid \text{yesterday} \) nonempty. For instance,

> It rained a while yesterday.

These cases thus exemplify how the generic vagueness of *yesterday* can be eliminated using explicit determiners:

> It rained at that point/some(time)/(for) a while/part of the time/occasionally yesterday.

> It rained all (day/through)/(for) the whole day/all the time/constantly yesterday.

Atomicity

Two valued logic is imposed on an event algebra when there is a morphism to the algebra 2. There are different ways of finding such a morphism. A truth definition or quantifier is one way. Genericity by quantifier which is ruled out. true and (wake

\( \text{wake}\{\text{sleep}\} \cap \text{all day} \) does not entail \( \text{wake}\{\text{all day}\} \cup (\text{sleep}\{\text{all day}\}). For suppose \( \text{wake}\{\text{sleep}\} \cap \text{all day} \) distributed over join. Then it would allow the case where \( \text{wake} \cap \text{all day} \) is true and \( \text{sleep} \cap \text{all day} \) false. In that case \( \text{wake}\{\text{sleep}\} \) would be half in and half out of *all day*, which is ruled out.
A loose (frame) time adverbial like \textit{walk today} walk \textit{in today} is the type of events occurring any time today. For loose adverbials, dual conditions hold. \textit{(walk\textit{in today} \cap (talk\textit{in today})\ does not entail \textit{walk\textit{in today}. i.e. walking sometime yesterday and talking sometime yesterday does not entail walking and talking at once. A tight adverbial commutes with its loose dual over negation. 

\textit{¬(sleep well\textit{in last night}) is equivalent to \textit{¬sleep well\textit{in last night. I did not sleep well last night means I slept unwell part of the night.}

Point time adverbials like at that point are atomary, and satisfy all the conditions of a Boolean homomorphism (Löbner 1990:16-17): (eUf) \cap t = (ef) \cup (ff)\cap t, (e\cup f) \cap t = (ef) \cap (ff)\cap t, \textit{¬(ef)\cap t} = \textit{¬ef}\cap t. One talks or listens at a point iff one talks at the point or listens at it, talks and listens at a point iff one talks at the point and listens at the point; and one does not talk at a point iff one shuts up at it.

\textbf{Truth value gaps}

The event type of states has the structure of a Boolean ideal (Halmos 1974). An ideal is a set closed under joins and subsets. A state \textit{s} is a complete ideal, which entails it is principal ideal generated by \textit{U}s. A Boolean principal ideal is a Boolean algebra, and so is the complement state, the principal ideal generated by \textit{U}s. The whole time line gets divided into two Boolean algebras, one for \textit{s} and the other for \textit{¬s}, so that any time is covered by a join of times in \textit{s} and \textit{¬s}. If \textit{s} is compact, time is divided into alternating connected stretches where one of \textit{s} and \textit{¬s} holds continuously. \textit{s} holds at those stretches where \textit{¬s} does not hold.

Since states are principal ideals, there is a (possibly disconnected) maximal or unit element, the state \textit{U}s. The event type \textit{s} is the Boolean algebra generated by \textit{U}s. Its null element \textit{¬U}s is the unit element \textit{U} of the complement state \textit{¬s}.

However, this particular cover of all time does not exhaust all the times there are. When we move to consider longer times, we find most times are not covered by either state alone. Such other times are covered by the mixed event types in (\textit{¬s U}s). This means that there are lots of times at which neither \textit{s} nor \textit{¬s} hold, for instance times of change \textit{¬ss}. This is the content of the claim that interval semantics entails truth value gaps (Hamblin 1971:97, Kamp 1981b:44, van Benthem 1982). Complementary states are are complementary on \textit{time} (points) but just contrary on \textit{times} (intervals). They do not divide up all \textit{times} between them, although they divide up all the \textit{time}. This type of truth value gap has little to do with vagueness, for it holds even if the boundary between the two states is sharp (contracts to a point).

Benthem (1982:§II.3, 1985:41-43) surveys attempts in the tense logical literature to juggle with valuations to preserve classical logic on all periods. It seems best to accept the fact that most event types do leave truth value gaps for most times. If I slept in little fits last night, I was neither asleep nor awake for the night (though I did both \textit{in} that night). This notion explains the duality of truth \textit{in} or \textit{at/for} a time. (Compare chapter on adverbials of time and Vlach 1979, 1981, 1993).

\textbf{Negation}

Antonyms create an Aristotelian square of opposites (van Benthem 1986:110, Löbner 1990:106) where a distinction between contradictory (outer, weak, periodwise) and contrary (inner, strong, pointwise) negation arises. The contrary of a state (as asleep to awake) is its antonym, \textit{¬s never asleep} of \textit{s always asleep}. The weak, contradictory negation \textit{¬s not always asleep} denotes times for which \textit{s} is not always true, i.e. at those times \textit{in} which \textit{¬s} is sometime true. The contradictory contains events not entirely in \textit{s}. The contrary contains events entire not in (disjoint from) \textit{s}.

\textbf{Figure 6}
The contradictory \(~s\) can be written as the relative complement \((s \cup \neg s)\)\(^*\). It is not a state, because it is not downward entailing (tokens of \(~s\) can contain tokens of \(s\)). \(~s\) entails \(~s\) but not vice versa. Both complements are self-dual (\(\neg\neg s\) and \(\neg\neg s\) equal \(s\)). The dual \(\neg s\) not never asleep of \(s\) asleep is equivalent to \(<s\) or sometime asleep. \(\neg s\) never not always asleep is equivalent to always asleep. A strong (tight, downward entailing, universal) event type \(s\) is a dual of a weak (loose, upward entailing, existential) one \(s\). This duality will come up in connection with time adverbials, for times too can be loose or tight (sometime yesterday vs. all yesterday).

The different negations identity \(\neg\neg\), \(\neg\neg\) or strong positive \(\neg\) (always), contradictory \(\neg\) (not always), contrary \(\neg\) (never) and \(\neg\) dual (sometime) form a Klein four group under composition (van Benthem 1986:110, Löbner 1990:72). Its multiplication table can be read off the square of opposites by following the lines of the above commutative diagram.

\[
\begin{array}{cccc}
\circ & s & \sim s & ~s \\
\sim s & \sim s & ~s & ~s \\
\sim s & ~s & \sim s & ~s \\
\sim s & ~s & \sim s & ~s \\
\end{array}
\]

Table 5

In this multiplication table, every operator is self-dual, identity is composition identity, and the multiplication of any two of the remaining three operators equals the third one.

A change \(ss\) is one corner of the square of opposites formed by the four group \((s \cup \neg s)^2\) (Ar. Phys 229b-230, Benthem 1986:110, Löbner 1984,1990)

\[
\begin{array}{cc}
ss & s\neg s \\
\neg ss & \neg s\neg s \\
\end{array}
\]

Table 6

The Boolean complement of a change \(ss\) ‘become’ with respect to the fourfield is \((s \cup \neg s)^2\) can be seen to be \(ss + 1\neg s\) ‘stay, stay not, or become not’.

The pointwise contrary of event type \(ss\) ‘stay’ is \(\neg s\neg s\) ‘stay not’, the dual is \(\neg ss\) ‘become’, and the contradictory \(ss\) ‘become not’, or perish. These four operators obey a Klein four group truth table.

Thus the pointwise complement of \(ss\) is the converse change \(ss\). Its contradictory in that algebra is \(ss\), the denial of a change. In this operation, the antecedent state \(s\) of a change \(ss\) is a lexical presupposition (Fillmore 1968, Givón 1972), i.e. it stays outside the negation, as if the change denoted its result \(ss\). Another way of expressing the point is to say that a change \(ss\) is the meet of a
presupposition \( \neg s < \) and an assertion \( ss, \) and its negation is the relative complement (difference) of the presupposition and the assertion \( \neg s \setminus ss. \) Given the presupposition, the complement reduces to \( \neg s \) which is open. For instance, the denial of \textit{leave} is \textit{stay}, of type \( ss, \) which is open.

The contradictory of a simple change \( e = \neg s \) relative to \( (sU\neg s) \) is the join of all other sequences in \( \neg s, \) i.e. the relative complement \( (sU\neg s)^* (\neg s) \) or

\[
(sU\neg s)^* \cup \neg(s\neg s)^* s \cup (sU\neg s)^* \neg s
\]

The general lesson of these considerations is that complementation is context dependent, relative to a background universe (van Benthem 1986:56). For states, \( \neg s \) is the complement of \( s \) relative to \( sU\neg s \) and \( \neg s \) is the complement relative to \( (sU\neg s)^* \). Relative to an algebra where event \( e \) is an atom, contrary \( e \) and contradictory \( \neg e \) fall together: the event is either all there or not at all.

Truth value gaps mean that event type \( sU\neg s \) is not \( 1 \) in all events (it is in discrete time), but \( sU\neg s \) and \( sU1 \) are. For the same reason, \( ssUs \neg s \) is not always \( 1 \), but \( ssUs \neg s \) is.

A consequence of the relativity of complement to algebra is the natural language fact that \textit{It always rains sometime} or its dual \textit{It sometimes always rains} are distinct event types, and both distinct from the one quantifier versions \textit{It always rains} or \textit{It rains sometime(s)}. (Note the singular-plural distinction in English between narrow scope durative sometime and wide scope frequentative sometimes.) \textit{It always} and \textit{sometime} ranged on the same domain here, one of the quantifiers would be vacuous. This observation is related to resolution. It will be subjected to closer inspection the section on temporal quantifiers.

The law of excluded middle does not hold of contraries so \( sU\neg s \) is not valid. But can any time be divided up into alternating periods of \( s \) and \( \neg s, \) i.e. is \( (sU\neg s)^* \) valid? Yes, for compact time (a space is compact iff every open cover has a finite subcover, Kelley 1951). It holds for finite time, for discrete time, and for closed and bounded subsets of real time.

An observation related to the duality of sometime against always or only is that \textit{it rained yesterday rain} or \textit{yesterday} denote anything between them, for it denotes the meet. Simple truth is a case of genericity. This is the topic of the next section.

\textbf{Consistency}

Truth is an explicit match between object language event types here, not an contextualised notion of truth at an implicit index as in Montague’s pragmatics. Otherwise put, indices become explicit event types (now). This will be covered more fully in the chapter on tense.

van Benthem (1996) recalls the Aristotelian view that truth is a relation between language and some aspect of the world, \textit{adaequatio ad rem}. The algebraic truth definition above makes no sortal distinction, but rather reduces truth to consistency between two descriptions of the same world.

Here is a duality of perspective between syntax and semantics, language and metalanguage, or local versus global variables. The semantic perspective, represented in full by Montague’s pragmatics, with modal and dynamic logic as examples, hides aspects of logical structure from view, or moves them from object language into a metalanguage, and studies logic of the remaining visible tip of the iceberg.

The syntactic perspective, represented by translation of intensional logic into classical logic, codes the index of evaluation in the object language as explicit parameter. It then deduces the form of the tip of the iceberg from the entire iceberg (classical logic) and the water (the translation).

Both perspectives are illuminating. The form of the tip may be interesting on its own right, witness modal logic. The translation may be interesting on its own right, and it allows applying known properties of classical logic to the nonclassical fragment.

The difference between the local and global variable (dually, the global vs. local situation) approaches is described in Rescher and Urquhart (1971:16ff) and discussed in Scott (1970:150) and Dowty (1982:44). It also ties up with our discussion of the notion of perspective later on.

\textbf{Truth and negation}

Positive means \textit{put}, Latin \textit{po-sinere} ‘set forth’. Positive means that there is something: an event type is instantiated by an event token, it is not empty. \textit{It is raining} means \textit{rain} \( > \emptyset. \) By duality, a weak

footnote 37: This idea can be generalised. It is possible to regard the participants of an event type as presupposed (invariant) parts of the event type. Thus the complement of \textit{it is raining here} is \textit{it is not raining here}, not \textit{it is raining elsewhere}. 
because operators are commutative or because a sequence of operators allows alternative decompositions due to associativity or duality. In combinatory categorial grammar (Lambek 1958) and Montague grammar (Montague 1968), the devices of lambda calculus (Church 1951) and combinatory logic (Curry and Feys 1968) for shifting operators about are used to the full (van Benthem 1985:§7, Landman 1991). On the other hand, on a fixed level of logical type hierarchy, operator orderings may only allow one solution.

I believe with Benthem (1986) that ad hoc type conversions and an associated loose or shifting notion of scope is a characteristic feature of natural language. It does not mean that natural language should never exhibit scope; there are phenomena which can be explicated by scope or order of operators. It means that in many cases, natural language expressions do not have fixed scope because operators are interchangeable, either because operators are commutative or because a sequence of operators allows alternative decompositions due to associativity or duality.

The English *any* is a case in point: *any* is one word in English though in many occurrences it is ambiguous between wide scope existential and narrow scope universal force. Logically, it can be

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38Number is covariant, singular and plural are not dually related. Constituent conjunction *he and she* is interchangeable with plural *they*.
shown that *any* must be a narrow scope existential in some of its uses, but a wide scope universal in others. A game theoretical generalisation covering all the uses is that *any* always marks an opponent’s move. There are many similar polarity sensitive dual purpose words in English and other natural languages.

Vagueness about scope is thus one important source of flexibility in natural language. We shall find many instances of this. In fact, I believe that both variability and invariance in the typology of natural languages can be explained by the existence of such meaning preserving permutations of operators. The idea that aspects interact compositionally and not (only) intersectively is not new (Verkuyl 1972, Lindstedt 1984, 1985, Dahl 1985:18), but it is not always appreciated. Failure to do so explains the belief that opposite aspects cannot be combined consistently, a belief which has been used as an argument for a strict separation of aspect and Aktionsart.

For instance, Bache (1985:94) claims that a distinction between aspect and Aktionsart is absolutely essential, because cases where both aspects (imperfective and perfective) are compatible with a particular Aktionsart can only be described appropriately if aspect and Aktionsart are autonomous categories (Bache 1985). Examples where open Aktionsart is compatible with perfective aspect or a bounding adverbial are taken to support the claim (Bache 1985:128). Johanson (1998:§10.2) spells out the implicit argument here explicitly:

…for example, the Bulgarian imperfective vs. perfective and Imperfect vs. Aorist distinctions are of different kinds. If perfective and Aorist are both defined as expressing "boundedness", whereas imperfective and Imperfect are both taken to express "non-boundedness", the combinations "imperfective Aorist" and "perfective Imperfect" get contradictory meanings that are impossible to account for.


The distinction between aspect composition and event type intersection will turn up here and there. Scope is relative to logical type. It is possible to represent a composition as a Boolean meet or conversely by juggling types appropriately, just as one can turn function-argument relationships around by raising type. But there will be a lowest type where the logic comes out right (Löbner 1990). For instance, Russian imperfective can be characterised as the composition of its various special cases or as an alternation between of them. Alternation is entailed by composition here, because the component aspects reduce to identity as a special case.

Reassignment of types affects scopes. An interesting case is the relative scope of iteration and meet. Consider *Deti umirali vse odin za drugim* 'the children all died one by one' (Forsyth 1970:156). This may seem at first blush a clear case of scope "for each child there was a time when it (alone) died". However, lifting types, the event type becomes a match of two disconnected event types, *one by one* and *children die*.

From the compositional point of view, two-level theories of aspect which separate ‘viewpoint’ from ‘situational aspect’ (Smith 1991) or ‘aspect proper’ from ‘actionality’ (Bache 1985, Bertinetto/Delfitto 1998) simplify aspect composition into a dichotomy, exploiting the empirical fact that more than two rounds of composition rarely get grammaticalised.

That semantics is no object is demonstrated by Partee’s (2000:488) series of aspectual constructs of increasing complexity: *write a letter every day for weeks every summer for years*…

**Topology**

It has not gone unnoticed that much of our talk about time and events involves inherently geometrical, specifically topological notions: openness or closure toward the past or future, continuity, adjacency, nearness and separation, distance, or remoteness. People talk of perspectives on an event viewing an event from the inside as extended, or from the outside, contracted to a point. This is clearly topological or geometrical talk (Rescher and Urquhart 1971:37).\(^\text{39}\)

Topology books (Kelley 1955) usually start out with point set topology, taking the notion of point as a primitive. Equally well, one can define a topology directly on open and closed sets and define points as

\(^{39}\)A topology is a set of subsets (the open sets) closed under unions and finite intersections. A set is open iff its complement is closed. Some sets are both open and closed (the empty set and the universe), some are neither (half-open and half-closed sets). The closure of a set is the meet of the closed sets containing it. The interior of a set is the join of the open sets contained in it. The boundary of a set is the difference of its closure and interior. In the discrete topology, every set is closed and open and its own closure and interior. There are no boundaries.

A topological space is a set of objects with a topology. A topology is a family of objects (open sets) containing 0 and 1 and closed under meet and complete join. The complement of the topology is its dual, the family of closed sets, closed under join and complete meet. An element which contains another element is one of its neighborhoods. The closure of an element is the meet of its open neighborhoods. The interior of an element is the join of open elements it contains. The boundary of an element is the difference of its closure and interior.

The distinction between point and region is a topological one. A region has a nonempty interior. A point is a closed element whose interior is 0. Two elements are connected if one meets the closure of the other, otherwise they are separated. An element is connected if it is not the join of nonempty separated elements.

A function in a topological space is continuous when it preserves complete joins and finite meets. A homeomorphism is a two-way continuous one-one mapping. Deformations, including contraction and dilatation, involve continuous mappings. For instance, a region can be contracted into a point if and only if it is connected.

Topological spaces and Boolean algebras are dual. More exactly, every Boolean algebra is isomorphic to a topological space. The set of all Boolean (2-valued) homomorphisms on a Boolean algebra A forms a topological space, the dual space of the algebra. Starting from the smallest Boolean algebras, 2 is the indiscrete topology. The two-element algebra 4 has discrete topology where all sets are both closed and open. The first Boolean algebra with nontrivial topology is the three-atom algebra 8, whose open sets are 0, 1, a, b, a+b, the closed sets are their complements. The only closed non-open set is the remaining atom c = ¬(a+b). This is the smallest algebra where a distinction between open and closed event types can be made. The open event type containing a, b, a+b is closed under joins, while the closed event type c = ¬(a+b) is atomary.

The class of all regular open regions of a nonempty topological space is a Boolean algebra with respect to Boolean operations defined so that the complement of a region is the complement of its closure, and the join of two regions is the interior of the closure of their join (Halmos 1974:13). For instance, the join of two adjacent open regions is their concatenation (their join plus the point in between).

Pin (1997) defines a metric topology on regular events. For more topologies on regular events see Pin (1991).

**Open and closed events**

One can in fact define a topology for the aspect calculus by defining an event type as open it is does not contain its boundary, closed, if it contains its bounds (Bennett 1981, Parsons 1983, Kuhn 1989:531). In general, e is open iff its complement is closed. In topology, open and closed are not a dichotomy: there are regions that are both (the empty set and the universe) or neither. Strictly, an event is closed if it is closed from both sides, and half-closed (neither open nor closed) if it contains its boundary from one side (Bartsch 1992:32).

My terminology will be topologically imprecise here: what I shall call closed event types are really topologically closed or half-closed. The distinction between closed and half-closed events is important in aspect theory, for it reflects the traditional distinction between bounded and telic events (Dahl 1981, Bertinetto/Delfitto 1998).

An open event token is of type a U aa U aaa U ... Its complement event type is ¬a U¬aa U a¬a U ¬aa¬a U a¬aa U ... These are precisely the different event types that can be formed from a and ¬a. In the limiting case when a is always or never true throughout a reference time a and ¬a are both open and closed.

To make this more precise, consider a sequence (aU¬a)^+ of alternating connected periods of a and ¬a. A base for the open sets of the intended topology are all factors of form a^+, so the set of open sets is the set of all subwords of (aU¬a)^+ of form a^+ (plus the empty set and (aU¬a)^+ itself). Closed sets are the complements of the open sets, i.e. event types in (aU¬a)^¬a^+. It is easy to verify that this defines a topology (open sets are closed under arbitrary joins and finite meets as required). This topology is the relative topology of (aU¬a)^+ wrt. a^+. It is a quotient of the usual topology of (aU¬a)^+. For the subspace a^+ it coincides with the usual topology, except that it makes a^+ connected (an event in ¬a between occurrences of a is closed and has no interior, i.e. contracts to a point). Relative to ¬a^+ it becomes the indiscrete topology. A closed factor is simply connected so it is contractible in the topology, while closed events separated by intervening occurrences of a are not.
Basic closed event types, as they are defined below, are actually (half-)closed factors of \((a \cup \neg a)^*\) i.e. (half-)closed and (simply) connected (singular count).

A series \(b^*\) of an event \(b\) closed relative to the topology of \((a \cup \neg a)^*\) is closed in that topology, but open in its relative topology of \((b \cup \neg b)^*\) The general lesson again: there is not just one event topology, but every algebra of event types defines its own topology.

A (half-)closed event type cannot be continued (in the closed direction) because it contains its bound. What is the \textit{bound} or \textit{boundary} of an event type? Intuitively, a bound is what stops an event from continuing, while a boundary lies between two events and separates them. A closed event is closed at ends by bounds, while one open event goes to another over a change that marks the boundary. A bound meets an event from one side, a boundary separates it from the other sides. A boundary can be contracted to a point, a bound can extended at will in the free direction. This ambiguity is preserved in the present topology. Strictly, the boundary between \(a\) and \(\neg a\) is the vanishing point of change where \(a\) goes over to \(\neg a\), the limit of my notion of change \(a \sim a\), which is a half-closed region. \(\neg a\) (together with the point of change) is really a bound of \(a\). However, in my book, when a closed event strictly contains its boundary (the change), it also loosely contains its bound, a bit of its complement event type, because the bounding event also contains the regions it separates. One way of making sound sense of this is to say that I am representing a point (more generally, a closed set) by the set of its open neighborhoods (its principal filter). My boundary-region representation of a change is thus the \textit{vague} representation of a point. As resolution is increased, my vague topology falls together with a standard one in the limit. (The same duality of points and their neighborhoods is involved in Russell’s derivation of points from periods: Russell 1926, Thomason 1979, van Benthem 1985:37.) Different aspects on the same change are obtained depending on which regions contract to a point: beginning (inception), end (achievement), middle (culmination), or both ends (cycle).

In my topology, the distinction between a point and region, between momentaneous and extended is related to concatenation. \(aa\) is extended because it consists of two adjoining open regions, while \(a\) in general is open but has no minimum extension. States, changes and cycles are all events, and closed events can be viewed both ways, as regions bounded by points, or as points bounded by regions. Given the elasticity of events, notions of \textit{momentaneous} and \textit{extended} have to be defined in terms of admissible range of variation: whether an event can be contracted to a point or not and whether it can be extended at will or not. An event type can be contracted to a point if it contains simple events of the same type, and it can be extended at will if its open subevents are unbounded. States can be both contracted and extended, achievements can be contracted to a point but not extended at will, activities can be extended at will but not contracted to a point, while accomplishments allow neither.

The common use of \textit{bounded/unbounded} in aspect literature (Partee 1984, Lindstedt 1985:134) is misleading. The intended distinction is one between \textit{closed/open} event types (events which contain their bounds and events which don’t, Smith 1991:100). In topology, boundedness does not imply closure (Kelley 1955:144). It is a notion of order or metric topology rather than general topology. A \textit{neighborhood} of an event \(e\) is an event temporally including \(e\). An event of form \(\langle e\rangle\) is a \textit{left} neighborhood of \(e\).

\textbf{Density and continuity}

Density and continuity are topological notions. An event is \textit{dense} if it meets with every nonempty open event. In other terms, a set is dense in a topological space \(X\) if the closure of \(A\) is \(X\). \(A\) is open in \(X\) iff the interior of \(A\) is \(A\).

Density allows for the inference of a place between any two separate places and the smoothness of motion. We have contiguity (adjacency) of neighboring places given in concatenation. Given density we can prove that \(go\) equals \(go\ go\) and \(go\ by\). Density is characterised by the identity \(a \subseteq a.a\)

which says that every token of \(a\) is divided into two of the same type. We might even consider a density operator \(^\wedge\) dual to iteration defined by \(a^\wedge = 1 \cap a.a^\wedge\)

and characterise dense event types as those satisfying \(a = a^\wedge\).

\textit{Continuity} of, say, motion (of place \(p,q\) against time \(t,u\)) can be expressed by the distribution identity

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\(^{40}\)Smith (1991:49) uses \textit{bounded} for events with arbitrary endpoints (cycles).
\[(p \cap t) \cap (q \cap u) = (p \cap q) \cap (t \cap u)\]

It says adjacent places meet at adjacent times.

**Incipit-desinit problem**

The classical and medieval *incipit-desinit* problem (*Ar. Phys.* VI.5, William of Heytesbury 1335, cf. Hamblin 1971:101) has not gone away. The problem is this: if states are always true or false pointwise there is no point left for a change of state to happen at (assuming change is an event *between* two states, Kamp 1980). Hamblin (1971:86) states the problem as follows:

At 8 am I get in my car and set off for work. At 7:59, before I started it, my car was at rest; at 8:01 am, it is in motion. When a thing is not in motion, it is at rest, and when it is not at rest, it is in motion. But what was the state of the car at 8:00 am, as I was starting it?

van Benthem (1982:4-5) points out that the problem of the dividing instant is not a problem for a period view of truth:

For one thing, on a pure period view, it does not make sense at all to talk about a dividing instant. The periods of burning/non-burning may be neighbours (in the sense that no period separates the two) without there being any ‘marker’ for the transition. This does not exclude periods overlapping both, even of a descending sequence of these. For such overlapping periods, indeed, it cannot be said truly either that ‘the fire burns’ or that ‘the fire is out’. But then, the two qualifications do not form an exhaustive pair for periods anyway, as these can record more complex happenings, like the dying out of the fire. (In a sense, that is exactly what periods are all about.) Thus, on the period view the problem evaporates.

Hamblin (1971) frames the problem as a clash between continuous-variable language and discrete two-valued language: if two-valued statements are predicates of time-instants they are discontinuous: they cannot flow smoothly from falsehood to truth in continuous time. On the other hand, if time is continuously mapped to a continuous change, then the change is open and the steady states are closed, as there is a first and last point of a steady state but no first or last point of change (there is no smallest difference). Hamblin agrees with Medlin (1963) that natural language seems noncommittal here. If the change is gradual, it can be seen as an open event bounded by two closed steady states; if it is instantaneous, it can be pictured as a dimensionless point bounding two states, belonging to either (or neither).

Galton (1984:33-34) votes for the latter:

At any moment just one of \(p\) and \(\neg p\) must be true, and therefore any change from \(\neg p\’s being true to \(p\’s being true must be instantaneous. ... When something starts to move, there is a last moment when it is at rest; at any earlier moment, it has not yet started to move, whereas at any later moment it has: this is the sense in which the change is instantaneous. But now a curious paradox arises, for it seems to follow from this that the last moment at which it is at rest is the moment when it actually starts moving. This is one of the paradoxes which led Hamblin to reject the idea of instants in favour of intervals (...), and in so far as this involves denying that the car starts at an instant I am in full agreement with Hamblin. I also agree with him that the correct assertion is that the car starts within an interval. I cannot join Hamblin, however, in concluding from this that we should call the sentence *The car starts moving* true of, at, in, or through an interval. ... although the change can only located within an interval, and not at a moment, it is still an instantaneous change because there is no lower limit to the length of intervals which contain it.

My solution is to treat both open and closed events as vague. van Benthem (1982:96, 1985:38) considers approximating the point of change through nested neighborhoods of this type (cf also *Ar. Phys.* 234a). Dowty’s (1979:140) solution is to define *become* so that it cannot be contracted to a point. My representation of change as a vague event converging to a point (a filter of events) combines both views. Cf. Lewis (1970), Kamp (1975), Fine (1975), Dowty (1979:88), van Benthem (1980:48ff) for approaches to vagueness in line with these ideas.

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41 Aristotle (*Ar. Phys.*236a9ff) argues that there is first point of a result state but no first point of a process. It is a topological theorem that the set of points where a continuous function is constant (or two continuous functions coincide) is closed (Halmos 1974:78).
Connectedness

Events can be connected or disconnected (Montague 1972:150, Bennett/Partee 1972, Bennett 1981:20, Johanson 1998, Link 1998:305). The formula $\overline{a \cdot a}$ denotes two stretches of a separated by $\overline{a}$. The event type is not connected in $a$, because it has an internal boundary towards $\overline{a}$. Or it denotes a connected stretch of $\overline{a}$ closed by $a$ on both sides. The distinction here is one between figure and ground, foreground and background. The quiet times in between form the background on which the events in focus take place. The course of events is the same, whichever selection of events is lifted out to be in focus.

Vlach (1993:245fn) notes time adverbials can denote disconnected times, e.g. *in my spare time, at daytime, now and then*. In my calculus a disconnected event can be represented in both ways, as a connected stretch of alternating events summed up by an iteration operator $(aU\overline{a})^*$, or as a disconnected collection of intermittent events $a:(aU\overline{a})^*$. Meets of iterated event types are often intended the latter way. (*When we dated boys they came to pick us up,*). Time measures like *minute* generate disconnected events because of their closure properties (cf. section on order).

Resolution

Granularity involves coarsening of the resolution of a sequence of events in that it preserves important features of the structure but leaves out detail. For instance, a workaholic restricts attention to events at the office leaving out all domestic ones, so that workdays seem to follow one another end to end. Under this resolution I will handle your order immediately can be true although there is a weekend in between. Even *What are you doing at the moment / right now?* is vague about granularity (Johanson 1998). The term occasion seems apt to refer to a bounded situation at a resolution suitable for each event type.

Coarsening granularity, or smoothing a course of events by leaving out irrelevant detail, is a quotient mapping which leaves out (maps to null) from a sequence of events those that don’t matter, making events that on closer look are not strictly adjacent appear adjacent. Conversely, the refinement of granularity takes an event algebra to a product algebra. These ideas can give practical content in the calculus, for regular languages are closed under transduction, substitution and (inverse) homomorphism (Salomaa 1973).

In the theory of regular languages, a connected subsequence $u$ of an event $xuy$ is called a factor and a connected sequence $u_1 \ldots u_n$ of nonadjacent factors is a (scattered) subword of $xu_1 \ldots u_n y$ (Rozenberg and Salomaa 1997:333). The class of regular languages is closed under factors (Rozenberg and Salomaa 1997:89) as well as under subwords (Rozenberg and Salomaa 1997:23,736). Scattered operators are regular in virtue of the closure of regular languages under morphisms and inverse morphisms, or equivalently, under finite transductions (Rozenberg and Salomaa 1997).

Since regular languages are closed under subwords, we can define another set of Booleans in the time dimension on the basis of the subword relation. The scattered join or shuffle operator (Conway 1971:59) $eU^*f$ is defined inductively by

$$xU^*\emptyset^* = \emptyset^*U^*x = x$$
$$xuU^*yv = x(u \cup^*yv) \cup^*y(xu \cup^*v)$$

The ignore operator of Kaplan/Kay (1994) and Karttunen (1994) is the special case of shuffle where one of the languages consists of strings of one symbol. Cf. *bshuffle* in Conway (1971:59).

Scattered meet or projection $eH^*f$ allows coarsening an event type $e$ into those subevents that meet some significant description $f$.

Scattered difference can be defined as the event type $e \setminus f$ satisfying the equation

$$(e \setminus f) \cup^* f = e.$$

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42 A set is connected if it is not the union of two nonempty separated subsets. Two sets are separated if neither intersects the closure of the other. A space is indiscrete if its topology is the trivial indiscrete topology (universe and empty set). The indiscrete topology separates nothing (everything is connected). A space is discrete if its topology is the discrete topology (points are open). A discrete topology separates everything (nothing is connected). In discrete spaces open sets are closed, so any two disjoint sets are separated.

43 Brugmann/Delbrück 1913:76 distinguish between iterative-durative event types, which are open and continuous, and repetitive event types, which are closed and discontinuous (Ikola 1949:37).
This operation formalises an erasure homomorphism as the scattered difference $e \setminus f$ of a significant foreground event type $e$ and an irrelevant background event type $f$. The equation

$$(a \cup \sim a) \setminus \sim a = a$$

relates the two ways of looking at an alternation of states as a connected event or a scattered join of disconnected sequences discussed above.

Scattered versions of other Booleans can be defined analogously. The scattered complete join or shuffle closure $U^e$ is the event type of all scattered subwords of $e$. $U^e$ is star free (Rozenberg and Salomaa 1997:23). For states $e$ and $f$, scattered join $eU^f$ equals $(eU^f)^*$. The scattered subevent relation between two events $e \subseteq f$ can be defined by $e \subseteq f = f$. This is a regular relation (Conway 1971:64). It allows defining a scattered version $in^\#$ of $in$ defined by $x : x \subseteq e$ which includes all scattered subevents of $e$. It is related to in by $in^\# e = U^f in e$.

Tokens of time (e.g. individual minutes) map onto a quotient algebra of times (or events) that last a minute. A minute, as a measure, or unit of counting, is a type of times, without a specific place in time.

In virtue of the second level of abstraction, times must be disconnected. Since minute is defined by duration, any two minutes are interchangeable, i.e. substitutable modulo duration. By implication, the events measured may be equally disconnected: work for 40 hours a week usually denotes a disconnected event type. Any disjoint join of sixty seconds is a minute, not only connected ones. Disconnected times are measured using connected sequences of periodic times (clock ticks) as a yardstick (Krantz et al. 1971).

Partitions of time in terms of periods of varying granularity relates to genericity. A generic event type such as work sums up distributions of activities on time under some given resolution. What is true under one resolution may be false under another one.

Changes of scale (choice of unit of measurement, say fractions of seconds or millions of years) are rigid affine (linear) transformations, a special case of homeomorphisms (continuous isomorphisms) which bend the metric of time smoothly but arbitrarily. Scale and granularity are interconnected through perspective.

**Point of view**

Perspective is a notion of projective geometry which studies reflections of a space. In projective geometry lines and points are dual and interchangeable: the dual of a point of view is the unending horizon surrounding it. A perspective is a point (line, plane) through which the surrounding space is reflected. Each point in the space is rotated or flipped over to a mirror image on the other side of the point (line, plane) of reflexion. The closer an object, the larger it appears; as it moves further away, it contracts to a point. If the point of view is inside a region, the region appears unbounded; if it is outside, the region recedes to a point. Such images, familiar from works on aspect, flow from the existence of morphisms to event algebra from the richer space of projective geometry.

In terms of projective geometry, a perspective fixes an origin, a point from which distances to other points are measured, a line of vision and a plane perpendicular to it where events are in sharpest focus. A projective space is preserved under projective transformations which map the space through a point and a line. Notions of point of view have had wide application in linguistics (deixis: Fillmore 1971, Gruber 1976, empathy: Kuno/Kaburaki 1977, Carlson 1988, diathesis: Delancey 1982).

Can we give some common characterisation for these different notions of point of view or perspective? We can start from the spatial metaphor, a space and a point of view as a point in that space, with distances measured from that point. Now replace the space image with that of a network of relations between individuals of any sort. A point of view is defined by choosing a designated member of the network. Its point of view on the network is a set of sentences that have a distinguished variable for it occurring in them (Langacker 1987:120ff.) A verbal description or narrative, can be solved relative to a selected point in it, rather like a geometrical space can be mapped through any one of its points.

The algebraic root of the notion of point of view is solvability or combinatorial completeness of an algebra. Instances are the combinatorial completeness of combinatory logic (Hindley/Selding 1986:109), lambda calculus (Hindley/Selding 1986:269) or categorial grammar, solvability of Boolean (Boole 1858), regular (Salomaa 1966, Salomaa/Xu 2000), or relational equations (binary constraint

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44Cf Lindstedt (1985:279): “The connection between aspectuality and temporal reference is due to the fact that reference can be made to a bounded situation only from an external time point.”
satisfaction, Ladkin/Maddux 1994), explicit definability in logic (Beth’s theorem), or the fundamental theorem of algebra (McLane/Birkhoff 1967:184). A set of equations in an algebra has a closed form solution if there are enough terms to name the solutions. What we are studying under the name of point of view is combinatorial completeness of natural language fragments.

Logical equivalences shift point of view. *Indexical expressions*: personal and demonstrative pronouns and tenses *(I, here and now, you, he, there, and then)*, indicate a point of view, systematically shifted in conversation and indirect speech. *Syntactic dependency*, for instance subject choice, main-subordinate clause relationships and referential chains define *foreground/background* relationships which reveal a point of view. *Lexical alternations* affecting argument structure, diathesis, and markedness relationships change point of view. *Perceptual and evaluative vocabulary* reveal the point of view of a perceiver and a preference subject. *Discourse structure* (what questions are posed, what inferences invited) reveals the background beliefs and interests of some attitude subject. Examples:

- **A** is in front of **B** / **B** is behind **A**.
- **A** gives **C** to **B** / **B** gets **C** from **A** / **C** is given by **A** to **B**.

Making a point of view explicit may reveal a hidden parameter or several: **A** is to the left reveals **A** is to the left of **B** as seen from **C**, **A** is good reveals **C** prefers **A** to **B** for **D**, **A** is big reveals **A** appears bigger to **C** than **B**, etc.

A particular perspective is associated with the direction of time. We face the future, move toward the future or the future flows toward us. Future events are in front of us, ahead of us and are drawing nearer. We are in the middle of things not yet past, and out of things that are already over, passing through events, while events pass by us into the past and the past recedes away. (Benveniste 1965, Traugott 1978).

Animals, subject to natural selection, have a natural perspective on events that puts me first, you second, and them in third place. This *person hierarchy* affects the choice among equivalent formulations in many places of grammar, from nominal reference (Carlson 1988) to voice (Croft 2001). It is a prefix of the *animacy hierarchy* discussed in the section on animacy.

**Aristotle’s principle**


> the movement in which the end is present is an activity. E.g. at the same time we see and have seen, understand and have understood, and are thinking and have thought (while it is not true that at the same time we are learning and have learnt, or are being cured and have been cured.) *Met.* 1048b:18ff.

Aristotle specifically derives this as a consequence of open events being topologically open so that every point *(is Ving)* is an interior point of *(Vs)*, with a left neighborhood *(has Ved)* of the same event type. *(Ar. Phys.* 236b, Bennett 1972:59).* If the open event is has some minimal granularity *(Link 1998:255)*, this inference is not strictly true, for at a fine enough resolution, the event appears discrete and closed with a first point where the inference fails, but it is true ‘at large’ or ‘soon enough’ *(Taylor 1977:214, Dowty 1979:172).* This is not to say that the aspects are without effect for open event types. Though the types match, for a given event token, progressive, simple and perfect do pick out different subevents. The focal (marked) cases are different: simple aspect covers maximal subevents, progressive interiors and perfect suffixes. Because of these differences, different and even opposite implicatures may arise in each case.

Viewed as a principle of modal or tense logic, Aristotle’s activity principle reflects the condition that the point of evaluation is an interior point in neighborhood semantics *(Segerberg 1971).* It is a consequence of Scott’s neighborhood semantics for the progressive tense *(Scott 1970:160).*

The converse of the activity *(energeia)* principle, the change *(kinesis)* principle **Vs** *(is Ving)* entails has not **Ved** holds for closed event types. As Aristotle put it:

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45Scott’s definition says **prog p** is true at t iff there is an open neighborhood **u** of **t** so that **p** is true throughout **u**. Scott notes that **prog** is not naturally definable in relational modal logic. Its logic is **S4**, whose characteristic theorem is **prog prog p ↔ prog p**, saying **prog** is idempotent. *(Scott 1970:160)*
In their parts and during the time they occupy, all movements are incomplete, and are different in kind from the whole movement and from each other. *Eth Nic.* 1174a21

The contraposition of Aristotle’s activity principle *has not* Ved entails *is not* Ving explains an implicature of present perfect. The contraposition of the kinesis principle, *has* Ved entails *is not* Ving is a common implicature of closed event types.

Aristotle’s principle also entails that one who *almost* Vs, hence has *not yet* Ved, *is not yet* Ving either.

### Time

Time $T$ imposes an order on events. An order is an antisymmetric binary relation of events. Its structure depends on further constraints on the relation, reflected in temporal axioms imposed on $T$.

There is a rich literature on this theme (Rescher and Urquhart 1971, van Benthem 1982, Burgess 1984).

Time is a dimension, or a quotient algebra, of event tokens. That is, there is a projection, or Boolean morphism, which sends each event token to the time at which it happens. Time can be directly constructed out of events by taking the morphism to be an insertion of event tokens to a subset of their power set. A time then is the set of events which happen then.

Time may or may not be actually defined as equivalence class of simultaneous events. An old theme is this: if nothing changes, there is no way to tell time, no way to tell eternity from an instant (McTaggart 1927). This idea fits the class of noncounting languages which cannot count times.

Time simplifies reasoning about courses of events by the equivalence

$$e \cdot f \text{ at } t \cdot u = e \text{ at } t \land f \text{ at } u \land t \cdot u$$

This separates information about the order of events from information about their Boolean structure. For instance, using the above equivalence, one can deduce the distribution of join over concatenation $(eUfg) = egUfr$ from the corresponding principle for Boolean meet.

A(n indicative) tensed sentence is true or false. It states that an event happens at a given time. In the model at hand, a complex event token happens at a given time if it belongs to the time, and an event type $p$ happens at $t$ if $p$ and $t$ intersect. A complex event $e$ happens in a given time $t$ if some course of events $xey$ happens at $t$.

The natural topology of the real line has a base consisting of all pasts and futures (called the order topology). An order is dense if there is a point between any two points. An order is complete if it is also completely distributive, i.e. join and meet are dually related: $x \leq y = \neg x \lor y$. A lattice morphism $h$ is continuous if $h(\emptyset) = \bigcup h(e)$.

Times in general are joins of periods. A period is a convex set of points. Two times $u,v$ are consecutive (adjacent) if $uv$ is a time. In my calculus, $uxv$ is a notational variant of $uxv$, i.e. $<$ is an anonymous free variable over events (including $\emptyset$ but not $\emptyset$).

Concatenation being associative, $tusu$ equals $(t<u)<v$ and $(t<u<v)$. The null event $\emptyset$ is concatenation identity, while the anonymous event $<$ is the Boolean unit $I$. For any event type $e$,

$$e = \emptyset e = e \emptyset \subseteq e$$

The notation reflects the duality of concatenation and order, which allows defining one in terms of the other. For $t$ to be *next to* $u$ means that $u$ is the nearest time after $t$, i.e. there is no time between them. Conversely, $t$ is (properly) *before* $u$ if there is a (non-null) time next to $t$ and $u$ is next to that. Concatenation is tight order, or dually, order is loose concatenation. (McNaughton/Papert 19)

I allow event variables $x$ and $<$ to denote the null event $\emptyset$ so that $t$ entails $t<u$. It follows that double $\ll$ equals $<$. I allow $\ll$ to abbreviate $\ll\ll$, which, denotes separate, remote or distant past, i.e. $< \ll \emptyset$. If $e_\ll <_\ll now$ some nonnull event separates $e$ from the present.

While before $<$ agrees with the inherent sense of the regular expression calculus, after $>$ does not. $>$ has a contextual definition by the equation $t,u \Rightarrow u<st$. Short of negative events going backward in time, we have no denotation for $>$ alone.\(^{43}\)

Hybrid combinations like $t<u$v or $t>u$v are ambiguous without parentheses:

\(^{43}\)An ordered set is convex iff it contains all points between any two points in it.

\(^{45}\)For inverse events, see Appendix 4. In regular language terms, $u>t$ is the mirror image language $mit(u>\cdot t)$ (Salomaa 1973:18).
Formulas \((t<\cap u)v = v \cap t < u\) and \((t>\cup u)v = u \cap t < v\) leave the order of \(t\) and \(v\) open. These forms will play a role in the analysis of past future and future past tenses.

Near past \(e.\text{now}\) holds events extending to the present. Near nonfuture is the event type \(e \cap \text{now}\) which means \(e\) covers \(\text{now}\) and an immediate past of \(\text{now}\). The term \(\text{extended now}\) McCoard 1978 and subsequent writing refers to such a \(n\) now extended to the near past. Extended now \(\text{now}\) differs in denotation from an immediate (near) past \(\text{now}\), which is a past continuing up to but not (necessarily) including the present (the main thing is that there is no gap between the past and the present).

Symmetrically we have near future \(e.\text{now}\) and \(\text{now} \cap \text{ne}\) for a near nonpast, i.e. present extended to the future.

If \(t \subseteq u\) were short for \(t \subseteq u \cup \text{t} \cap u\), it would not allow \(t\) to partially overlap with \(u\). It is better to define \(t \subseteq u\) differently. A good choice is \(t \subseteq \cap u\) which has the first definition as a special case. This one says \(t\) is no later than \(u\): \(t\) starts no later than \(u\) and ends no later than it. In other terms, \(t \subseteq u\) is the smallest interval including \(t\) and \(u\).

The two definitions coincide when \(t\) and \(u\) are atomary. \(\leq\) alone does not denote a real event type, but it can be defined contextually: \(\leq\) equals \(\leq t\) or \(\leq t\) or \(\leq v\), and \(\leq\) equals \(t \cap v\) or \(t \subseteq v\) or \(t \leq v\). The event type \(e \cap \text{now}\) is a near nonfuture, denoting events which overlap a suffix of \(\text{now}\) (i.e. the endpoints of \(e\) and \(\text{now}\) coincide).\(^{48}\)

In acyclic time, time’s arrow is irreversible: the same time never returns. Times are token identical (atomary) with respect to concatenation, and antisymmetric with respect to order:

\[
\begin{align*}
\neg t, t &= 1 \\
\neg t &\subseteq \cap t \\
\neg t \subseteq t &= t \\
\neg t \subseteq (t \cap u) \\
\neg t \subseteq (t \cap u) \\
\end{align*}
\]

Note also that \(e \cap f = e \cap f\) for incompatible events \(e \cap f = \emptyset\), and \(t \leq t = t \cap t = t\) for times or event tokens \(t\).

**Eternity**

Eternity, always or forever may also be an event type. Positive eternity future or henceforth is the event type \(1^o\) or \(\leq^0\) of events going to go on forever. The omega exponent produces a maximum (perhaps infinite) number of iterations (Perrin 1984, Pin 1991, Rozenberg/Salomaa 1997). Negative eternity past or hitherto is the event type \(1^-\) of events having gone on forever. Eternity ever or always is the concatenation past now future.

Eternity ever is thus a dual to the event type of \(\leq\), meaning sometime. The adverb forever, is literally the event type for ever. in and for are dual, which means among other things that ever = in for ever.

Finite automata allow a dual characterisation of the event type forever. An automaton all of whose states are exit states produces a prefix closed language. Its complement, an automaton with no exits produces the empty language. Generalise the notion of language generated by an automaton to the set of all finite or infinite words which can be homomorphically mapped to the automaton (Salomaa/Rozenberg 1997). Looping automata without exits describe events which go on forever.

The regular language operator omega \(\omega\) is a dual of Kleene star \(*\). In the extended domain of infinite strings, the complement of the empty language includes infinite languages over the alphabet: \(\neg \emptyset = 1^o\), and \(\neg (e^o) = (\neg e)^o\). Another equivalent characterisation of eternity is until the end of time, or more generally, \(e^o = e\) until \(\emptyset\).

The complement of future is nonfuture past now and its order dual is past. A Boolean dual of future is in future in the future or eventually. What does not go on forever eventually ends. The Boolean dual of past is in past in the past. Another paraphrase which falls out from these stipulations is for the future meaning henceforth. Note also the paraphrase for the time being = for now.

\(^{48}\) Cresswell’s connective ‘and then’ \(t\) and \(u\) (Dowty 1979) denoting a minimal period satisfying \(t \subseteq u\) can be defined as \(\cap t \subseteq u\).
If future branches, what happens eventually does not have to happen any specific time. What is meant is the universal-existential quantification must in future e or must <e: in every future there is a time when e happens. (See section on liveness and safety.)

Declercck (1997) is an approach to tense which operates with such time-spheres and sectors. (See section on TMAD systems.)

**Boundedness**

It will be important to note that future <e and past e< of an event have no beginning and end, respectively, so they are unbounded to the past/future. This is the common mathematical sense of bounded. In aspect literature, the term is often used for what I (and mathematicians) call closed.

In linear time, it does not make sense to ask since when it is true that an event will eventually happen if it will. A near future is bounded, for soon e is true from some short time before e until e. In forward branching time there can be a bounded foreseeable, impending or certain future, for there can be a first time at which the event will happen in the sense that it has become inescapable (it happens in all future branches). It is not any one time, for different events become (un)certain at different times.

A past e< has a beginning just at the end of the event e, but no end. A near past He has just left ought to be bounded. If time is backward linear, there is no notion of bounded certain past symmetric to impending or certain future. But a case can be made that natural language evidential and mythical past constructions code such a notion. (See section on evidentiality.)

This will help understand the combinatorics of tenses with adverbials.

**Now**

Jespersen (1924) suggests that now can denote an extended time, not a point but a region now*, now now* round the time of speaking, an open neighborhood of a point (Palmer 1987:§3.1.3, 3.2.2., Abusch 1998:21, Guillaume 1929: Ch.IV, Kuhn 1989, Declerc 1997:62):

"Theoretically, it is a point, which has no duration, anymore than a point in theoretic geometry has dimension. The present moment, “now”, is nothing but the ever-fleeting boundary between the past and the future ... But in practice “now” means a time with an appreciable duration, the length of which varies greatly according to circumstances ... (Jespersen 1924:258, cf. also Cohen 1989:81).

On the other hand, now has no minimum duration. As Aristotle (Ar. Phys. II.3) argued, the present can be contracted to a point. These characterisations make now aspectually a state (simple and open). This insight will come to use in the section on simple present. Formally, now satisfies the identity

\[
\text{now} = \langle \text{now} \rangle = \text{now}^+.
\]

Thus technically, now ranges from vanishing point of present to the extended now <now< containing all time round it.

Jespersen’s observation about open now is important for understanding open perfects like I have been waiting for you. Overlapping atomless event types are simultaneous and adjacent at once: r< entails r>s. Given wait and now are open, present wait<now< equals progressive wait<now<, extended now wait<now<, near past wait now open perfect wait now, simple past wait <now and existential perfect wait<now. This is an important locus of neutralisation. There is a generalisation lurking here relating the two senses “round now” and “so far” of extended now. (see section on paradigm).

The distinctions concerning now are quite subtle. They may make a difference as to what is entailed about the present. For instance Portuguese não saiu ‘he did not go out/he hasn’t gone out’ is vague about it. One translation only excludes a proper past (does not quantify over now), the second one extends to the present. If a negative perfect(ive) does not cover the present, then the positive form can be narrowed to a proper past. The intended coverage is figured out in context by game theoretical reasoning (Carlson 1983). Compare section on markedness.

The English free present tense does not denote an extended now in the technical sense. It cannot replace the perfect in I have been here since yesterday yesterday<now<here. It will turn out that as a dependent tense, the English simple present can denote an extended now.

At the same time, the English simple present is transparent to event type, so if the time denoted by now is shorter than the event around it, progressive must appear: I am running. now<in run.

Languages without the progressive distinction just don’t make the distinction. For instance, fi Juoksen ‘I run, I am running’ does not distinguish between a simple match now<run, an unmarked progressive
now \cap \text{in run} \text{ or unmarked extended present } \text{run now} \cap \text{ run 'I run about now'. These are equivalent, given now and run are open.}

Jespersen’s open now is not the only event type now can have. Just like its distal counterpart then, now can match any event type. It is open when the time of speaking is open, that is, when we are speaking about the status quo. In Now it comes or now I dropped it we are speaking about events. In a narrative, now can also refer to the narrative present (Rescher/Urquhart 1971:33). The now of the following sentence is not the deictic centre of the narrator nor that of the prosecuting attorney, but a third one belonging to the story being told:

\begin{quote}
It was 3 o’clock in the morning when the old lady rang for the nurse on duty. The prosecuting attorney claims that the nurse was tired now, and didn’t pay much attention to the old lady.
\end{quote}

More on this in the chapter on tense in discourse.

Order of events

Intervals can be temporally related in seven ways. Here is a picture of the options:

| \text{t} & \text{u} | \text{Simultaneity} | \text{t} \cap \text{u} |
| --- | --- | --- | --- |
| \text{t} & \text{u} | \text{proper prefix} | \text{t} \cap \text{u} |
| \text{t} & \text{u} | \text{proper suffix} | \text{t} \cap \text{u} |
| \text{t} & \text{u} | \text{proper infix} | \text{t} \cap \text{u} |
| \text{t} & \text{u} | \text{proper overlap} | \text{t} \cap \text{u} |
| \text{t} & \text{u} | \text{Contiguity} | \text{t} \cap \text{u} |
| \text{t} & \text{u} | \text{proper separation} | \text{t} \cap \text{u} |

Table 7

Corresponding improper relations are obtained by replacing separation \text{«} with temporal order \text{<}. More relations are obtained by taking Booleans and mirror images of these, for instance \text{t < u} equals \text{t u U t = u}. The event type \text{t u in 1 = t < f < u <} is the join of the lot. \text{<} is a partial order in the set of event tokens and transitive for event types. However, it is not asymmetric for arbitrary event types. It is possible for \text{e < f} and \text{f < e} to hold at once (for different tokens). For instance, when I walk I move my left foot both before and after my right foot. The application must be here before five allows, and probably also expects that the application must be here after five.

The relations correspond to ways to lift an order relation on points to a relation among extended events, with different logics (Tedeschi 1981:264fn, van Benthem 1982:9, Ladkin/Maddux 1994). The simplest ones (Hamann 1989) are listed below. The operators \text{V, A} can be read as lattice glb and lub with respect to temporal order.

1. \text{t} \text{ starts before } \text{ u} \text{ starts} \quad \forall \text{ t < u} \\
2. \text{t} \text{ ends before } \text{ u} \text{ ends} \quad \text{At<Au} \\
3. \text{t} \text{ starts before } \text{ u} \text{ ends} \quad \forall \text{ t < Vu} \\
4. \text{t} \text{ ends before } \text{ u} \text{ starts} \quad \text{At<Vu}

Dual versions are obtained by replacing before \text{<} with not after \text{<}. A combination worth singling out is \text{t u (4)} where \text{t} ends before \text{u} starts. Another is \text{t u} where \text{t} starts and ends no later than \text{u} does (1+2).

Different properties of the underlying order are lost in the different definitions. The weakest definition 3 (overlap) is symmetric, so it is hardly an order at all. Definitions 1 and 2 preserve linear order by ordering events by designated points. The strongest one 4 loses transitivity of complement, turning the order of events into a partial order.

Compare
John stretches before and after he runs.
I was betting (even/only) before the horses were running.
I was betting (even/only) after they were running.

The first sentence compares two closed events using the end<start rule 4 (Heinämäki 1974). The second sentence with before compares two beginnings using the start<start rule 2 (Miller/Johnson-Laird 1976, Ritchie 1979) while the third sentence with after follows start<end rule 1. Adding only forces rule 4, even blocks it.

There is a connection between ordering rule and aspect here, predictable from the characterisation of open and closed aspect in terms of meet and join. Open events obey the weak any rule: an event may precede one token of an open event type and follow another one:

Odd numbers come before even numbers.

John worked at IBM both before and after you did.

Closed events obey the strong all rule: if an event precedes or follows a closed event at all, it precedes or follows all of it.

The following connections between aspect and order are predicted by these considerations:

- open < open \ start<end
- open < closed \ start<start
- closed < open \ end<end
- closed < closed \ end<start

Everything works as predicted as far as after is concerned. The exception is before: an open event type in a before clause often appears closed, as if it were in the scope of an implicit closure operator:

We left before it was (i.e. got) dark. (Heinämäki 1974:69)

This asymmetry between before and after is well known (Anscoume 1964, Heinämäki 1974, Hamann 1989:91). Before and after are asymmetric in natural languages in that before is a negative polarity context but after is not. I return to this in the section on before and after.

The characterisations of order types in terms of lattice operators predict their behavior on Boolean joins and meets. < is preserved in meets but lost in joins. A precedes B and C precedes D does not entail A and C precede B and D except respectively. ≤ is preserved in joins and meets:

There is a duality between sorting (total order) and permutation (partial order). A partial order corresponds to a set of total orders or permutations. A single ordered pair in a domain is a partial order too, so it too is the set of all permutations it belongs to. The more order, the fewer permutations. The complement of a strict linear order is a the mirror image non-strict order. The complement of a partial order is partial order only if it is total.

**Asymmetry of time**

Time flies like an arrow. We move in time from the past through the present into the future, facing the future, living in the present, and leaving the past behind us, while future time comes forever toward us becoming first present then past (Traugott 1978, 1985). Even if we agree that time is an asymmetric in the sense of an asymmetric order relation (a directed arrow), we can still argue whether it is symmetric round the present. Even if we are sure that time never returns, can we tell which way it is going? (Reichenbach 1956.)

Here are some of the many indications that past and future are not symmetric over the present.

- Existence. Past and present are already there, future is not.
- Nondeterminism. Past and present are necessary, future is possible (contingent).
- Future tenses come from modals, pasts not.
- Causation. Cause cannot follow effect (the past cannot be changed).
- Backtracking counterfactual conditionals are rare and fail prone (Lewis 1979, Nute 1984:418).
- There is a preparatory process but no postparatory process. There is a future progressive is going to V but no perfect progressive is having Ved.
- Imperfective paradox of the progressive: is Ving entails has started Ving but not will finish Ving.

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49 This observation has consequences for narrative progression: an open event type does not have to end for another event to follow it.

50 Example: If Hinckley had been a better shot, Reagan would be dead vs. backtracking If Reagan were dead, Hinckley would have been a better shot. There are more degrees of freedom about the future.
• Unfinished objects: destroying an object entails the object existed, creating an object does not entail it will exist (Parsons 1990)
• Imperfective paradox of before: leap is entailed by leap after you look but not by look before you leap.
  • before is a negative polarity item, after is not: French ne appears with avant, not with après.
  • before can be counterfactual, after not: French uses subjunctive with avant, indicative with après.
  • When means (immediately) after rather than (immediately) before.
  • (Immediately) after grammaticalises more often than (immediately) before (Gruzdeva 1994).
• Past future would is counterfactual (conditional), future past will have been is not.
• Perfective paradox: perfective can denote the beginning of an open event or the complete event, not just the end (Talmy 1985:92, Smith 1991:79).
• There are fewer verbs denoting cessation than inception (Ar. Phys. 229a26, Löbner 1988).
• Time adverbials denote change or its final state but not the initial state (Schopf 1987)
• Time’s arrow: there is a fixed association of past/present/future with source/location/goal rather than vice versa.
• Orientation of perspective: past is behind us, future is ahead of us.
• Events take time. Free time is in the future. When events come about, time is used up.
• Direction of positive scalar implicature: already means earlier or more than expected (scales increase toward future).
• Narratives proceed from past to future.
• Languages make more tense and aspect distinctions in the past than in the future (Ultan 1978).
• The present perfect-simple past distinction is not mirrored in the future (Ikola 1949:49).
• Perfect (past) participles moritus ‘dead’ are common, prospective (future) participles moriturus ‘going to die’ rare.
• Sequence of tense exists for the past but not for the future (Comrie 1976, Fabricius-Hansen 1989).
• Temporal and conditional clauses allow perfect but rarely future. before/after he has arrived is common, future before/after he will arrive is unusual.

Basically, asymmetry of time is the division of events into those that are already there and those are not yet there relative to some now. Conversely there is (free, unused) time in the future, just because there are no events (yet) there. Time is where events take place.

Aristotle’s principle for open events is backward looking too: it says that an open event has begun, not that it will continue or end.

Time is directed from past toward the future, so it goes (passes us, here and now) from future to past. Temporal order is based on the pasts, or initial suffixes, of events. e < f means there is a past of some now that contains e but not f. The minimal and maximal subevents (lower and upper bounds) of an open event type relative to directed time are its beginning and the complete event. A change < ss is not definitely there before it is over and its final state s holds. This is why any change is primarily a change into a state, and any state is primarily the end state of a change. The asymmetry of time thus explains why the perfective of an open event can denote the beginning or the complete event, but not just the end.

Real time is isotropic, hence symmetric (van Bentham 1982:37): there is no way to distinguish past and future from the structure of time, thus no explanation for the asymmetry. That explanation must come from a combination of time and modality. The direction of causation: cause cannot follow effect, is really just a restatement of time's arrow.

A genuine source of asymmetry is nondeterminism: backwards linear, future branching time. The wide end of time has less information and more entropy.24 We gain information, the world at large loses it as time goes by.25 These notions have been studied for the tense logics they imply (Thomason 1972, van Bentham 1985, Burgess 1982,1984:§6.2-6.4).

Anisotropy only concerns temporal order (McTaggart’s B series before/after). In contrast, now, the fixed point of McTaggart’s A series past/present/future, is not an absolute, structural feature

---

24 The connection of the direction of time to the second law of thermodynamics has created a large literature in and around physics. The question is by no means settled.
25 Intensional information about and extensional information in an event are dual (Reichenbach 1957).
The ternary relation *y is between x and z* reduces to two asymmetric transitive binary relations *x is before y and y is before z* (Russell 1903:217). As van Benthem (1982:13) shows, McTaggart’s two series are thus interdefinable: the step from B to A involves contextualisation (choice of index), the step from A to B decontextualisation (making explicit reference to the index). Classical Kripkean model theory for Priorean tense logic reduces the A series to the B series, see van Benthem (1982:154). The reduction is analogous to the interdefinability of the positive and the comparative in the theory of adjectives, and that in turn is the correspondence of binary first order relations and second order choice functions (Fishburn 1977). Choice functions are asymmetric, because the rejects of a choice are not chosen: there is a center and the edges.

McTaggart’s A and B series are dual. They can be diagrammed as the duality of three points and two line segments connecting them. The two segments are symmetric and complementary, while there is an asymmetry about the three points: one is *inside* or *between* the other two.

**Priority**

An interesting but less studied Boolean operator is *priority join* (Kaplan and Kay 1994), which I will symbolise as

\[ e \text{ } \cup\text{ } f \]

and read as *e if possible else f*, or equivalently as *e or f if necessary*. It is defined by the formula

\[ (e \neq \emptyset \cap e) \cup f \]

which equals \((e \neq \emptyset \rightarrow e) \cap (e=\emptyset \rightarrow f)\) or \((e \neq \emptyset \cap e) \cup (e=\emptyset \cap f)\). In other words, it denotes *e* if *e* is nonempty and *f* otherwise. The definition of priority join is quite classical. But the operator is not commutative nor associative, unlike usual join. Rather, it compares to the procedural interpretation of Booleans in imperative programming languages or the English connective *else*.

Priority operators are nonassociative and noncommutative, and nonmonotone in the first argument, so it makes a difference in which order they apply: *e U? f* is distinct from *f U? e* and *e U? (f U? g)* is distinct from *(e U? f) U? g*. I will assume priority join associates to the right, so *e U? f U? g* is short for *e U? (f U? g)*. Distributivity also fails: \((e U? f) \cap g = (e \cap f) U? (f \cap g)\).

**Priority meet** *e \cap? f* is read as *e and f if possible*, and defined by

\[ e \cap (e \cap f = \emptyset \cup f) \]

In other words, it is the meet of *e* and *f* if it is nonempty and *e* otherwise.

The complement of priority join is \(\neg(e U? f)\) which comes down to \((e \neq 1 \rightarrow e) \cap (e=1 \rightarrow f)\) read as *e if necessary and f*. It denotes *e* if *e* is not foregone and *f* otherwise. It defines the same preferences as priority meet.

Priority meet is interdefinable with priority join:

\[ e \cap? f = (e \cap f) \cup? e \quad \quad e U? f = (e U f) \cap? e \]

The interdefinability extends to longer sequences, as typified by

\[ e \cap? f \cap? g = e \cap f \cap g \quad e \cap f \cap? e \quad \quad e U? f U? g = e U f U g \quad e \cap f \cap? e \]

Priority meet is left associative. The priority of event type *e* over its complement \(\neg e\) is expressed by *e U? \neg e*, which is equivalent to *e U? 1* and to \(1 \cap? e\).

As these equivalences show, priority meet and join invert the order of priorities: priority join starts with the best option and bargains down, priority meet starts with the minimum and bargains up. Priorities stated in terms of meet are easier to apply: take the status quo and bargain up from it. Priority join is decreasing, and meet is increasing.

53 PACE Bull (1960:10), Lyons (1977:684) and Harkness (1987:72), absolute dates (with fixed origin like 1997) are not indexical (do not depend on *now*), though relative dates (June 10) are.
The first step,  \( e \) if possible, expressed in terms of priority meet, is \( e \cap f \), which denotes \( e \) if nonempty, else 1. The exit clause of a priority join is the equivalent event type \( e \cup f \) also read \( e \) if possible Then
\[
  e \cup f = e \cup (e = \emptyset \cap f) = (e \cup e = \emptyset) \cup (e \cup f) = (e \cup f) \cap (e \cup f)
\]
which shows that priority join is compositionally definable as \( e \) or \( f \), but \( e \) if possible. Its complement \( \neg(e \cup f) \) thus says neither \( e \) nor \( f \), or not \( e \) though possible. Translated to preference terms, either \( e \) and \( f \) are not preferred, or else \( e \) is not preferred over \( f \).

### Test events

Priority join can be characterised by the notion of a test event from dynamic logic. The test event \( ?e \) or \( \text{true} e \) (may \( e \)) asserts \( e \) is nonempty. That is, \( ?e \) is the event type \( e > \emptyset \) which denotes 1 if \( e \) is nonempty and \( \emptyset \) otherwise. It is the order-preserving morphism from a Boolean algebra to 2.

The complement of \( \text{true} \) is false (\( \neg \text{may} \)), which obeys the equivalences
\[
  \text{false } p = \neg \text{true } p = \text{true } \neg p = ? \neg p = \neg ?p
\]
The dual of \( \text{true} e \) is the event type \( !e \) or must \( e \) which denotes \( e = 1 \) (always, all, only, must). Its complement is \( e < 1 \) which equals \( !e \) or \( \neg ?e \) (maybe not \( e \)). This four group is threshed out more fully in the section on truth.

The relation of test event to priority join is given by the derivation.
\[
\begin{align*}
  e \cup? f & \equiv e \cup? f \subseteq e. \\
  e \cap f & \equiv e \cap f \subseteq e.
\end{align*}
\]

The conditional \( ?e \rightarrow e \) here expresses the notion \( e \) if possible. So the last formula shows priority join can really be written and read as the meet \( e \) or \( f \), and \( e \) if possible. Thus in particular the simple preference \( e \cap 1 \) ‘\( e \) or don’t care’ equals \( ?e \rightarrow e \) ‘\( e \) if possible’.

### Derived operators

Once order counts, there is a host of derived priority operators. **Priority difference** \( e \setminus f \) is defined as \( e \cap \neg f \). It removes \( f \) from \( e \) if possible. Its dual is **priority conditional** \( e \rightarrow f \) defined by \( \neg e \cup f \). **Priority residual** \( e \leftarrow f \) is defined by \( e \cup f \neg f \). The fourth corner of the fourfield, inverse priority difference \( \neg e \cap f \) has no shorthand.

Four items already allow 4! or 24 permutations. There is no need to name all of them. For instance, the expression \( (e\cap?f) \cup ?(f\cap?e) \) codes the order \( (e\cap?) \cup ?(f\cap?) \cup ?(\neg e\cap?) \cup ?(\neg f\cap?) \) and \( (e\cup?) \cup ?(f\cup?) \cup ?(\neg e\cap?) \cup ?(\neg f\cap?) \)

I define **priority sum** \( e +? f \) as the event type
\[
(\neg e\cap?) \cup ?(f\cap?) \cup ?(e\cap f) \cup ?(\neg f\cap e).
\]
It prefers exclusion over equivalence, and beyond that the leftmost term. **Priority equivalence** \( e \leftrightarrow f \) will be defined as
\[
(\neg e\cap?) \cup ?(\neg f\cap?) \cup ?(e\cap f) \cup ?(f\cap e).
\]
It prefers equivalence over exclusion, and beyond that the leftmost term. Priority only makes sense if there are options: \( U \) reduces to \( U \) in 2. The multiplication tables for priority join/meet look like this.
Table 8

It is easy to see that priority operators reduce to the usual Booleans in the two-valued algebra 2.

**Priority iteration**

Consider the generalisation of priority operators to concatenation. Optionality $p$ is defined as the join $\emptyset^+ \cup e$. This yields two prioritised versions, a positive one $e \cup ? e$ once if possible and a negative one $\emptyset^+ \cup e$ once if necessary.

Given that $e'$ can be defined as $e \cup e^+$, priority iteration or priority closure $e^\omega$ and $e^\omega$ ‘as long/often as necessary’ ought to be defined as $e \cup e^\omega$ and $\emptyset^+ \cup e^\omega$, respectively. It codes a preference for the shortest possible iteration of $e$. Its dual $e^\omega$, as long/often as possible, defined by $\emptyset^+ \cap e \cap e^\omega$, codes the opposite preference for as long an iteration as possible. One who likes an activity $a$ holds the preference

$$\neg a^\omega \Rightarrow a^\omega$$

read as ‘as soon as possible and as long as possible’. One who hates it holds the opposite preference $(\neg a)^\omega \Rightarrow (\neg a)^\omega$ ‘put off as long as possible and put an end to it as soon as possible’. Impatience is expressed by $((\neg a)^\omega a^\omega)^\omega$ and perseverance by $(\neg a^\omega a^\omega)^\omega$. Lexicographic order of words in $(a \cup \neg a)$ becomes simply $(a \cup \neg a)^\omega$.

An interesting case is *lenient transduction* defined in terms of priority join as $f \cup ? x : x$, or equivalently in terms of priority meet as $x : x \cap ? f$. It transduces $x$ into $e$ if possible, else does nothing. Note the equivalences

$$f \cup ? (x : x) = (f \cup ? x : x) = (x : x) \cap ? f = x : (x \cap ? f)$$

*Lenient composition* $f \circ ? g$ can be defined as composition with lenient transduction, i.e. as $(f \cup ? x : x) \circ g$ or $x : x \cap ? f \circ g$. *Iteration* of a transduction $f^\omega$ is understood as iteration of compositions of $f$, or of $f \cup f$ if $f^\omega$. *Priority iterations* of a transduction $f^\omega$ and $f^\omega$ prefer fewer and more iterations, respectively.54

Complete priority join and meet are not worth a notation. To the extent they make sense, they are expressed by $\cup e$ and $\cap e$, respectively.

**Strict priority**

Reflexive priority $e \cup e$ or $e \cap ? e$ reduces to $e$. Symmetric priority $(e \cup f) \cap (f \cup e)$ reduces to $e \cap f$. The consistency of these preferences shows that priority operators code a preorder.

Unlike usual Booleans, $e \cup ? e$ is contingent and $e \cap ? e$ consistent (it is equal to $e$). Note that $\cap 1$ is well formed and true, as are $? 1 = 1$, $1 = 1$, $\neg ? \emptyset$, and $? \emptyset = \emptyset$.

$e \cup ? e$ is the same as $e \cup 1$ or $1 \cap ? e$ or $\neg e \rightarrow e$ and the opposite of $\neg e \cup ? e$, $\neg e \cup ? 1$, $? e \rightarrow e$, $1 \cap ? e = e$, $1$ shows indifference.

54The transducer identity $p : x = \emptyset : x$ equals the transduction $(p = \emptyset) : x$. Its inverse is $x : (p = \emptyset)$, which from the abstraction perspective is the event type $x$ for which $p = \emptyset$. This allows characterising priority join of transductions $p : x$, $q : x$ by the equation

$$ p : x \cup q : x = p : x \cup (p : x = \emptyset : x \cap q : x) $$

This joins to $p : x$ the meet with $q : x$ of the events which $p$ maps to $\emptyset$, which in this case equals their composition (cf. section on transduction).
The complement of a preference \( e \cup f \), the event type \( \neg(e \cup f) \) comes down to \( \neg e \cap \neg f \), ‘not e and f if e is possible’. It is the same as opposite preference when indifference is transitive (preference is a weak order). In particular, the complement of a simple preference \( \neg(e \cup f) \) becomes \( \neg e \cap \neg f \) and equals \( \neg(e \cup f) \) or \( \neg(f \rightarrow 1) \cap \neg e \) or \( \neg e \cup \neg f \) ‘e is possible e yet not e’.

Strict preference, i.e. preference for e over f and dispreference for the other way round, is expressed by

\[
(e \cup f) \cap \neg (f \cup e)
\]

which can be also written as \((e \cup f) \setminus (f \cup e)\). A simple strict preference for e becomes

\[
(?e \rightarrow e) \cap \neg e \cap e
\]

This says ‘e if possible and e even if \( \neg e \) is possible’. An equivalent idiom is \((?e \rightarrow e) \setminus (?e \rightarrow \neg e)\).

Use \( \mathcal{S} \) for a shorthand for \((?e \rightarrow e) \) and \( \mathcal{S} \) for strict preference. Strict preference is transitive, so \( e \mathcal{S} f \mathcal{S} g \) is well defined and entails \( e \mathcal{S} g \).

Priority meet \( e \cap f \) is a tensor product (Pratt 1999), a noncommutative fibred product subject to the law \( e \mathcal{S} f \geq \emptyset \) and characterised by the Galois connection

\[
e \cap f \leq g \text{ iff } e \leq f \rightarrow ? g
\]

**Heyting algebra**

Consider defining \( \text{true} \) e as \( e \mathcal{S} \neg e \) ‘rather e than not’. Under this truth definition, we do not get a full Boolean algebra, but a Heyting algebra. Heyting algebra is a subset of Boolean algebra. It is a distributive lattice which satisfies the conditions

\[
x \rightarrow x = 1 \\
x \cap \emptyset = \emptyset \\
x \cup \emptyset = 1 \\
(x \rightarrow y) \cap y = y \\
x \cap (x \rightarrow y) = x \cap y \\
(x \rightarrow (y \cap z)) = (x \rightarrow y) \cap (x \rightarrow z) \\
(x \rightarrow y) \rightarrow z = (x \rightarrow z) \cap (y \rightarrow z).
\]

Heyting algebra is the algebra of partial information, modal and intuitionistic logic, vagueness and fuzziness, truth value gaps, and topos. (van Benthem 1985,) It fails the classical laws of bivalence (tertum non datur), double negation, modus tollens, de Morgan, and Peirce.

These observations help relate the asymmetry of time to Aristotle’s futura contingentia principle, according to which future is nondeterministic: (some) future events are not determined (neither true or false) before the fact. Define \( \text{must} \) e as \( e \mathcal{S} \neg e \) ‘rather e than not’. Then an event is determined if \( \text{must} e \cup \text{must} \neg e \) holds and \( \text{contingent} \) if the dual \( \text{may} e \cap \text{may} \neg e \) holds. A weak futura contingentia principle says that only future events are contingent:

if \( \text{may} e \cap \text{may} \neg e \) then \( e \)

A strong futura contingentia principle strengthens this to an equivalence, or adds the converse

if \( \text{may} e \cap \text{may} \neg e \) then \( e \)

These principles can be stated in the reverse:

\( \text{must} e \) if (and only if) \( \leq e \)

The strong only if direction is implicated in the use of present or past tense to describe future events as in \( \text{you have lost the game/ your chances/ You are dead/ I’m gone.} \)

This only begins to unleash the value of priority Booleans. There are other mind expanding applications in the horizon, including vagueness, comparatives, markedness, and pragmatics.

**Games**

Priority operators will come to use in the sections on counterfactuals, causality, markedness and prototypes. They are are the algebraic counterpart of binary order relations and choice functions for expressing comparative notions. A priority join defines a strategy, or choice function. A join of choice functions is a strategy set, which is equivalent to a game tree. This equivalence creates a correspondence between the algebraic calculus and the game model of modal logic introduced later on.

Priority operators satisfy the following identities:
Define a strategy as an event type $\sigma$ defined in terms of priority operators. The composition $\sigma \pi$ of strategies $\sigma$ and $\pi$ is their priority meet $\sigma \cap \pi$. An event $e$ is a degenerate case of a strategy. Note that $e \sigma$ does not entail $e$, while $e \sigma$ does. The strategies defined in terms of priority operators are pure strategies. As choice functions, they reveal a lexicographic preference relation (Lehmann 1995, Williams 1996, Benferhat et al. 2001).

I exemplify the representation of games with priority operators by encoding three well-known games Left or Right (Even or Odd, Battleship and Merchant Ship), Prisoner’s Dilemma, and Battle of Sexes (Chicken). (Howard 1971).

*Left or Right* is a two-person zero-sum game with imperfect information. One player hides something in either hand behind his back. The other player gets it if he guesses the hand. The preferences of the hider and the guesser are expressed by

$$
\text{I left.you right} \cup \text{I right.you left} \cup \text{I left.you left} \cup \text{I right.you right}
$$

despite. The meet of the preferences is $\emptyset$ (the game is zero-sum). The strategies of the hider are $\text{I left.}$ and $\text{I right.}$, the strategies of the guesser are $\text{I left}$ and $\text{I right.}$ The outcomes are all the meets of the player strategies. Although the guesser moves last, his strategies do not depend on what the hider does (the game has imperfect information). The players might as well move simultaneously, in which case their strategies would be just $\text{I left}$ and $\text{I right}$ against $\text{you left}$ and $\text{you right}$ (Carlson 1994).

What a player can do with a given strategy is what the strategy guarantees against the entire strategy set of the other(s). For instance, the guesser’s strategy $\text{I left}$ brings about

$$
\text{I left} \cap (\text{you left} \cup \text{you right})
$$

i.e.

$$
\text{you left.I left} \cup \text{you right.I left}
$$

which does not guarantee a win. Neither player has a winning strategy in this game. The best play is to guess at random (a mixed strategy).

Compare the same game with full information. The hider chooses first and the guesser knows the choice. The hider’s strategies are as before, but the guesser has four strategies, including the winning strategy

$$
\text{you left.I left} \cup \text{you right.I right}
$$

The meet of this strategy and the hider’s entire strategy set

$$
\text{you left.I left} \cup \text{you right.I right} \cap (\text{you left} \cup \text{you right})
$$

is again the winning strategy, which is the guesser’s optimal outcome.

There are at least three ways to win a game. One is to be stronger. Another is to be cleverer. A third one is not to care. The game of *Left or Right* with imperfect information is a draw: neither player has a winning strategy. The same game with full information makes the guesser stronger.

Another way of ensuring the guesser a win is to give him two guesses. This gives him more power without adding his knowledge. He does not need to know because one of the two guesses wins anyway. The game consists of three moves. The preferences over the outcomes for the hider are

$$
(\text{I left.you right.you right} \cup \text{I right.you left.you left})
$$

$$
\cup
$$

$$
(\text{I left.you left.you right} \cup \text{I left.you right.you left} \cup \text{I right.you right.you left} \cup \text{I right.you left.you right})
$$

The preferences for the guesser are the opposite. He now has the strategy $\text{I left.I right}$ whose meet with the opponent’s strategy set gives

$$
\text{I left.I right} \cap (\text{you right} \cup \text{you left})
$$
which equals the event type

\[ \text{you left.I left.I right } \cup \text{ you right.I left.I right} \]

which is optimal for the guesser.

The third way to win is to change the preferences of the game so that a loss becomes a win. Trivially, the guesser has a winning strategy if he gets the gift whichever way he guesses, or if he does not care, i.e. if his preference relation does not distinguish between outcomes.

Prisoner’s dilemma is the game of cheating between sexes. For good biological reasons, he and she have opposite preferences about faithfulness. It is best if I cheat and you don’t, next best if neither cheats, then if both cheat, and the worst is if you cheat and I don’t. Both players’ preferences are coded as either of the dual forms

\[
(\neg \text{you cheat } \cup ? \text{ you cheat}) \cap ? (\text{I cheat } \cup ? \neg \text{I cheat})
\]

\[
(\neg \text{you cheat } \cap \text{I cheat}) \cup ? (\text{you cheat } \cap ? \text{I cheat})
\]

These define the preference ordering

\[
(\neg \text{you cheat } \cap \text{I cheat}) \cup ? (\neg \text{you cheat } \cap \neg \text{I cheat}) \cup ? (\text{I cheat } \cap \text{you cheat}) \cup ? (\neg \text{I cheat } \cap \text{you cheat})
\]

The composition of the preferences in either order produces a different optimum. The meet of the two players’ preferences is the joint preference

\[
(\neg \text{he cheat } \cap \neg \text{she cheat}) \cup ? (\text{he cheat } \cap \text{she cheat})
\]

Again neither player can alone bring about what is best for both. The solution is to team up and cooperate. The problem here is that the cooperative solution is unstable.

Both players have the first order strategies \( \text{I cheat}, \neg \text{I cheat} \). The outcome \( \neg \text{he cheat } \cap \neg \text{she cheat} \) is stable for the male if it is no worse than \( \text{he cheat } \cap \neg \text{she cheat} \). Which it is not. So \( \neg \text{he cheat } \cap \neg \text{she cheat} \) flips over to \( \text{he cheat } \cap \neg \text{she cheat} \). This is table for the female if it is no worse than \( \text{he cheat } \cap \text{she cheat} \). Which it is not. So it flips over to \( \text{he cheat } \cap \text{she cheat} \). This is stable for the male because it is better than \( \neg \text{he cheat } \cap \text{she cheat} \). Symmetrically for the female. So the stable equilibrium is \( \text{I cheat } \cap \text{you cheat} \), which is worse for both. Two independent agents reach a worse equilibrium than they would if they were one agent.

The solution singled out by natural selection seems to be a mixed strategy: be faithful most of the time and cheat at random only so much that the other partner does not bail out of the deal.

The preferences of the Battle of Sexes are expressed by priority equivalence. By the usual story, the spouses prefer to do the same thing but each prefers different things: the man likes games, the wife opera. Simplifying this a bit, the wife wants out, the man does not. The wife’s preferences are coded as the priority equivalence \( \text{I out } \leftrightarrow ? \text{ you out} \), equivalently expressed as

\[
((\text{I out } \leftrightarrow \text{ you out}) \cap ? \text{ I out}) \cap ? \text{ I out}
\]

saying ‘I’d rather for us to do the same thing, and if possible go out, else I go out’. It produces the preference ordering

\[
(\text{I out } \cap \text{ you out}) \cup ? (\neg \text{I out } \cap \neg \text{you out}) \cup ? (\text{I out } \cap \neg \text{you out}) \cup ? (\neg \text{I out } \cap \text{you out})
\]

The man’s preferences are symmetrically opposite \( \neg \text{I out } \leftrightarrow ? \neg \text{you out} \). The composition of the preferences in either order produces a different optimum. The meet of the preferences

\[
(\text{she out } \leftrightarrow ? \text{ he out}) \cap (\neg \text{he out } \leftrightarrow ? \neg \text{she out})
\]

is the joint preference of going to the same place

\[
((\text{he out } \leftrightarrow \text{ she out}) \cup ? (\neg (\text{he out } \leftrightarrow \text{ she out}))
\]

What they disagree about is the best implementation of this event type. Neither player can alone bring about what is best for both. One solution is to team up and flip a coin, i.e. to form a joint agent we who uses a mixed strategy to equalise between the two equilibria. Another solution is to split up so going together is no longer a shared goal (preference deterioration, Howard 1971:200).
For the present concerns, the main point of interest is the formalisation of the game-theoretical reasoning using priority operators. The argument is If he does not cheat and she does not cheat then he cheats. Classically, this is just false, because if he does not cheat then he does not. But this is a counterfactual argument: suppose cooperation; the male preferences and his choices, what would the male do (next)? To know that, we must remove from the premises what is needed for the male to have a choice, and then determine his choice from his preferences and strategies.

**Except**

Look at a typical exception in a timetable:

I wake up daily at eight except Sundays at ten.

What *except* does is takes out as little as possible from the general rule that precedes that is necessary to make room for the exception that follows. In the case at hand, the result is easily defined in Booleans over times as

\[(\text{day} \cap \text{eight} \setminus \text{Sunday}) \cup \text{Sunday} \setminus \text{ten}\]

In other words, take out *Sunday* and put in *Sunday at ten* instead. The expression can be rewritten as

\[(((\text{weekday} \setminus \text{Sunday}) \cap \text{eight} \setminus \text{Sunday}) \cup \text{Sunday} \setminus \text{ten} \]

Consider next the dual of times, event types, as in The weather is fine except it is cold. What we want to see is a parallel between the following reductions:

- any day (weekday or sunday), except sunday  \(\Rightarrow\) weekday.
- fine (warm and dry), except not warm  \(\Rightarrow\) dry.

Say *fine* is defined as *warm* \(\cap\) *dry*. The dual substitution operation should subtract *warm* using residual and add *cold* using meet. That operation is not expressible by simple dualisation. The candidate

\[(\text{fine} \leftarrow \text{warm}) \cap \text{cold}\]

reduces to

\[(((\text{warm} \setminus \text{dry}) \cup \neg\text{warm}) \cap \text{cold}\]

\[(((\text{warm} \cup \neg\text{warm}) \cap (\text{dry} \cup \neg\text{warm})) \cap \text{cold}\]

\[1 \cap (\text{dry} \setminus \text{warm}) \cap \text{cold}\]

\[(\text{dry} \setminus \text{cold}) \cup \text{cold}\]

Here is what is going on. Extensional *except* is Boolean subtraction. Intensional *except* is its dual, feature subtraction or abstraction. This operation is not expressed as a boolean function of the terms of *except*, because the universe relative to which the subtraction is taken is a dual universe of features. To abstract a feature is to subtract an element from a dual Boolean algebra of features. To do so one must fix the dual base of features relative to which the subtraction happens. Assume the complement is taken relative to the feature space *warm+dry*, giving

\[((\text{warm}+\text{dry})\setminus\text{warm})+\text{cold} = \text{cold}+\text{dry}\]

The calculation then proceeds as indicated in

\[(((\text{warm} \setminus \text{warm})+ (\text{dry} \setminus \text{warm})+\text{cold} = (\emptyset + \text{dry})+\text{cold} = \text{cold}+\text{dry}\]

which works because atomic features are disjoint *dry*\(\setminus\)warm = \(\emptyset\), so dry\(\setminus\)warm = dry. The exact dual calculation

\[(((\text{warm} \setminus \text{dry})\leftarrow\text{warm}) \cap \text{cold} = \text{cold} \setminus \text{dry}\]

\[(((\text{warm} \leftarrow \text{warm}) \cap (\text{dry} \leftarrow \text{warm}) \cap \text{cold} = (1 \cap \text{dry}) \cap \text{cold} = \text{cold} \setminus \text{dry}\]

goes through just when *dry*\(\leftarrow\)warm = dry or dry\(\cup\)warm > \(\emptyset\). This condition changes the last few steps of the original failed reduction so that the desired subtraction is obtained. A definition of
subtraction \( e \text{ except } f \) where \( e \) and \( f \) are event types can thus only be given relative to a factorisation \( e = f \cap g \), where it is the event type \( g = (e \leftrightarrow f) \cap (f \cup g) \). It can be expressed as a complete Boolean function

\[
\cap p: \text{fine} \subseteq p \setminus p \subseteq \text{warm}
\]

where \( p \) ranges over the features of the base. In the case at hand, this formula instantiates to dry.

Daily except Sundays means almost the same as daily except not Sundays. The same duality holds for all but (not) one. The meaning is not quite the same: Everyone agrees except you (not) entails you disagree just when not is there. The logical form without not is (everyone except you) agrees, where except operates on objects. With not it is everyone agrees except you do not agree, where except operates on event types. The difference seems to be one between a subtraction and a substitution.

Consider event type There is dirt here except (not) there (pointing to one place), represented by the event type

\[
\text{dirt here} \setminus \text{dirt there} \leftrightarrow \text{dirt there}
\]

The deletion removes the region of dirt there from the event type, and the addition adds the opposite event type. The above event type is equivalent to

\[
\text{dirt (here\(\setminus\)there)} \cup \text{clean there}
\]

where the subtraction is factored into the location subtype.

The dual behavior of not in except clauses gets an explanation from the above construction. The negation reflects the positive half of the substitution operator, its absence the negative half.

The substitution except is idempotent, so I came except I came means just I came. Except reduces to meet when the exception clause is consistent with the rule: Everybody came except I was late entails just Everybody came and (but/though I was late, if I did come. You came except everybody came reduces to everybody came. Except reduces to just the exception clause if the exception leaves nothing over of the rule: I came except I did not is just a correction boiling down to I did not come. come\(\leftrightarrow\)come—come is just ~come.

Except as construed here subsumes Boolean difference in the following sense. For instance, exclusive we can be defined in terms of Boolean difference we\setminus you ‘we excluding you’, or just ‘we and not you’. The deletion can be equivalently although redundantly characterised in terms of except as substitution with \( \emptyset \)

\[
\text{we} \setminus \text{you} \cup \emptyset \text{‘we except (not) you’}. 
\]

which equals taking out of us the minimum necessary to entail ‘not you’.

**Nonmonotone inference**

The notion of substitution of events in the above argument, removing a premise to add another, links priority to nonmonotone and counterfactual inference and causality. An argument If I were you, I would be rich substitutes the hypothesis I am you in a set of premises, i.e. removes premises which contradict the hypothesis and adds the hypothesis (Ramsey 1931, Ryan/Schobbens 1997)

Application of the Ramsey rule can be construed as a maximisation problem. Intuitively, the corrected wakeup time contains besides the exception the maximum of times which meet the rule and are disjoint from the exception, i.e. something of the order of

\[
\cup t: (\text{day}\cap \text{eight}\cap t \setminus \text{Sunday})
\]

Dually, the intensional except not event type contains besides the exception the maximum of event types which meet the rule and are compatible with the exception, i.e. something of the order of

\[
\cap p: \text{fine} \subseteq p \setminus p \subseteq \text{warm}
\]

We can think of this as the closest event type to fine weather compatible with the exception. This perspective is applied in conditional modal logic.

The maximum may be empty. For instance, say I am poor and you are rich: if I were you would I be rich or would you be poor? If I were you I would be rich. If you were me you would be poor. Consider this case as an exception event:

\[
\text{I am poor, you are rich, I am not you. What if I were you?}
\]
As the dual of the extensional characterisation of except, this event type comes to

\[
((\text{I poor} \land \text{you rich} \land \neg I=you) \lor I=you) \land I = you
\]

i.e.

\[
\text{I poor} \land \text{you rich} \land I=you \\
\text{I poor} \land I \text{ rich} \\
\emptyset
\]

The last step is based on the logical truth of poor+rich. The same result can be obtained by looking at the definition of the exception event as the minimum of different ways of accommodating the exception.

\[
\bigcap p : (\text{I poor} \land \text{you rich} \land \neg I=you \land p \lor I=you)
\]

What can \( p \) be? We must drop \( \neg I=you \) because it contradicts the exception. But what else to drop and what to keep? The consistent choices for \( p \) are

\[
\text{I poor} \land I=you \\
\text{you rich} \land I=you
\]

But the meet of these is empty, so the maximum is \( \emptyset \). Unless we can agree on priorities, there is no saying what else would happen if I were you and you were me.

Given priorities, a most preferred, or closest counterfactual event type can be found. For instance, if the priorities over our assumptions are given by the strategy

\[
\text{I poor} \land ? \text{you rich}
\]

then the exception event type becomes \( I=you \land I \text{ poor} \).

One can factorise the premises into laws, boundary conditions, and consequences and give priorities to them in this order. Perhaps I am poor because I am me, while you are rich because you are different from me. Then the premise set is something like

\[
\neg I=you \land (I=you + you rich) \land I \text{ poor}
\]

The substitution of \( I=you \) is consistent: I stay poor, while you, being me, get poor too.

**Dualities**

The inverse relationship between except and counterfactual conditional is patent in

The weather is fine except it is cold (not warm).
The weather would be fine if it were not cold (warm).

Ryan/Schobbes (1997) point out the dualities among different nonmonotone operators. My summary and interpretation of their results in the present terms is this. The belief revision modality used to capture counterfactual inference is my priority meet (cf. section on strategies above). The update operator is the dual substitution operator except, which turns out to be the inverse (right-to-left mirror image) of priority join. Thus the following duality diagram is obtained.

<table>
<thead>
<tr>
<th>Dual</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>inverse</td>
<td>substitution in meet</td>
</tr>
<tr>
<td>priority meet</td>
<td>priority join</td>
</tr>
</tbody>
</table>

**Table 9**

Priority operators order terms in decreasing order of priority. Substitution operators order terms in increasing order of priority. Priority meet adds information until it fails. Priority join detracts information until it succeeds. Meet substitution always keeps the last information. Join substitution always retracts the last information.
Order
Order begins with a(nti)symmetry. With transitivity, or acyclicity, it gives the category of (strict) partial orders, a cartesian closed category with monotone (order-preserving) functions as morphisms. The linguistic category of comparison involves order relations too: a comparative property reveals an order relation.

Order relations appear in many guises. These include concatenation, binary order relations, choice functions, priority operators, and metrics. (Compare also section on convolution.)

In this section, I try to relate alternative ways of looking at order.

Looking at the signatures of preference relations, choice functions and priority operators on a Boolean algebra \(A\), they are respectively

\[2^{A \times A} = 2 \leftarrow A^2 \quad A^A \quad A^{A \times A} = A \leftarrow A^2\]

The types grow going from left to right, so denotations must be constrained to let the operations on the right match or reveal those on the left. In the Boolean algebra 2, they all boil down to 16. There are 16 (all of them preference) relations, choice functions and Boolean operators in 2. Priority Booleans reduce to the usual ones here. As the size of \(A\) grows, the properties of preference relations cut down the number of relations in the first signature, followed by similar cuts in choice functions and binary Boolean operators.

(i) There is a straightforward morphism between binary order relations and concatenation, described more fully in the section on relation algebras. One consequence of the morphism is the equivalence

\[x \leq y = x \subseteq \bigwedge y\]

(ii) The suffix operator \(\setminus\) is a choice function. It satisfies the choice function properties of reflexivity, transitivity and co-transitivity. Any event is its own prefix (reflexivity). The prefix of a prefix is a prefix (transitivity). The non-prefix of a non-prefix is a non-prefix (co-transitivity).

\begin{align*}
x\setminus\setminus x & \subseteq x & \text{Reflexive} \\
x\setminus\setminus (x\setminus\setminus x) & \subseteq x\setminus\setminus x & \text{Transitive} \\
x\setminus x\setminus \setminus x & \subseteq x\setminus\setminus x & \text{co-transitive}
\end{align*}

The event type

\[\neg p < p\]

is equivalent to that specialisation of \(\setminus\) which applied to the choice set \(-p<\) includes \(p\) but not \(-p\). This means that a motion or direction event type can also be read as a representation of a preference. The event calculus codes the notion that one who goes somewhere prefers it there. The encoding of the will and the action is the same, it is a question of how the event type is read.

(iii) Priority Booleans define choice functions. The strategy followed in the previous example is

\[1 \setminus? < p\]

which is just the choice function described in (ii). Mapping the choices on time, this represents the development of a nondeterministic future from an open choice point to a branch where \(p\) is chosen.

Strategies thus are choice functions. As shown in the theory of revealed preference (Fishburn 1977:299), a choice function reveals a preference relation by the definition

\[y \leq x \iff \sigma(x \cup y) = x.\]

This preference relation defines a dyadic modal operator on event types by the formula

\[c \sigma w \rightarrow e\]

which says that strategy \(\sigma\) brings about \(e\) given \(c\) and \(w\) (Hansson 1969, van Fraassen 1972, Lewis 1969:103). This will be put to use in the chapter on mood.

The family of choice functions over a set of options forms a monoid under composition, with the identity choice function as unit. This allows defining notions of strategy composition and strategy combination. Simple strategy choices are not commutative: it is better to know what the other player has chosen before making one’s own choice. Game theory works with commutative strategy sets, where strategic advantage is coded in the complexity of each player’s strategy set. This amounts to a
type shift, or skolemisation of operator orderings. In a commutative set of strategies, strategy composition reduces to pointwise meet, so $\sigma \pi$ equals $\sigma \cap \pi$ (Carlson 1994).

Composition with a simple proposition $p$ equals the meet of $p$ and the choice set when nonempty and 1 otherwise. (It is a two-way partition, a special case of a choice function determined by a equivalence relation, Fishburn 1977, van Benthem 1991). The complement $\neg \sigma$ of a choice function $\sigma$ can be defined as the function choosing the complement of what $\sigma$ chooses. Similarly for union, so we have a full Boolean algebra of strategies.

Finally, we can define inclusion or entailment between strategies $\sigma \subseteq \pi$ as $\sigma \pi = \sigma$. This amounts to saying that $\sigma$ is a refinement of $\pi$.

**Multiattribute measurement**

Multiattribute measurement (Krantz et al. 1971), involves projecting a set of preference relations into a single preference relation. Looking at it another way, it concerns defining an order on a vector space.

One special case is where the attribute dimensions are orthogonal and the composite preference is a lexicographic ordering of the component preference relations $p, r$. The lexicographic order follows $p$ when the two orders are incompatible and $r$ when $p$ is indifferent.

$$p \cup (r \setminus \neg p)$$

The relation can be represented equivalently as a strategy whose value at any set of options is a priority meet $\sigma \cap \pi$ of the values of the component choice functions $\sigma, \pi$. For instance, the lexicographical order of the event types $aa, ab, ba, bb$ can be defined positionwise as follows.

$$(a \cup b) \cap (\neg a \cup \neg b) = (aa \cup ab \cup ba \cup bb)$$

(A tabular proof is given in the appendix.)

Lexicographical preference considers the dimensions of choice orthogonal: no increase in the less important attribute can offset the preference on the more important one. In terms of multiattribute measurement, the weight of the second criterion vanishes relative to a positive weight on the first one. (the ratio of the weights is 0).

Another special case is where the attribute dimensions satisfy cancellation or joint independence so that a preference in one dimension can always be offset by preferences on other dimensions. In this case, the composite preference can be expressed as a linear combination of the attributes and measured in reals as a weighted sum of the component preferences. (Fishburn 1996). This corresponds to the assumption that the dimensions are not orthogonal, but skewed (have a positive projection on one another).

These two extremes are thus dual to one another: joint independence is dual to orthogonality.

**Summary**

The smallest Boolean algebra $2$ is a small order relation of 0 and 1, or yes or no. Any nominal scale is a product of $2$ (see section on categorisation), an element of one is a vector of $2$ (a characteristic function, or valuation).

A finite binary relation is a Boolean algebra whose atoms are isomorphic to $2$, or ordered pairs. At the same time it is a fibred product of two monadic Boolean algebras under the laws of anti-symmetry and transitivity.

The laws allow extending a binary order relation to both Boolean (commutative and idempotent) and relational (concatenation) products of the relation. An order relation on atoms is extended to one on arbitrary elements through the choice function representation. An order relation on pairs is extended to an order relation on sequences so that any prefix of a sequence precedes its suffix. Conversely, a binary order can be retrieved as the revealed binary relation or as a convolution (shifted product) of binary cuts on a set of sequences.

The laws also allow defining metrics, or morphisms from the order relation to the algebra of reals. The slack (invariance) of the metric depends on the laws of the order relation in well known ways.

A multiattribute order relation in turn is a product of binary orders, or equivalently, an ordered vector space. There are two types: lexicographic, where the vectors are orthogonal and the dimensions ordered, and linear sum, where the vectors are not orthogonal and the points are ordered so that there is a weighted linear metric on the components.
Order connects up with language theory. Comparison is context free. To sort objects by size one has to form a monotone map between two orders. Context free languages are formalised in monadic second order logic with two successor functions against one for regular languages. See section on trees.

Grammar
A concrete way to represent natural language as a formal language is the original Montague plan of giving construction and inference rules directly for natural language (Benthem 1986). For instance: from \( x \) gave \( z \) infer \( x \) gave \( y \) to \( z \), \( z \) got \( y \), and \( y \) went from \( x \) to \( z \); from \( x \) gave \( y \) to \( z \) infer \( x \) had \( y \) before \( z \) had \( y \), and so on. The advantage is minimum of theoretical baggage. The disadvantage is a proliferation of similar rules for different items. In category theoretic spirit, it is more common to look for universal elements for the similarities, and abstract a formal language to represent them. Semantics and rules of inference are given once for the formal language plus translations between it and the natural language. But the two points of view can also be combined, construing natural languages as an alternative syntax for an abstract calculus.

Dualities in grammar
The opposition between syntax and semantics, rules of formation and rules of interpretation, proof theory and model theory is a duality which goes to the core of modern logic. In a way, my approach is at odds with this tradition, or at least can be seen as an attempt to straddle the duality. I do not fix the syntax of the event calculus at the outset, but extend it as need arises. I do not fix a semantics or set of intended models for it at the outset either, but allow myself to move from one framework of concepts to another as need arises. Like Russell’s old lady, I like to think of my world as being constituted of event and object types in the manner of “turtles all the way down”: there is always room for more distinctions, no rock bottom semantics to stop at and map a fixed syntax on.

Largely, this is a statement of attitude. But it translates to descriptive options in places. For instance, I suspect n-level theories for any fixed small n, like two-level aspect (Smith 1991), three-index tense (Reichenbach 1947), or three-level diathesis (Genusiene 1987). If more than two levels of decomposition are needed, why stop at three? Why not rather “turtles all the way down”? Language does not count. Or so I believe.

Syntax too can be done in two dual ways, known as generative grammar and constraint grammar, respectively. Context-free languages and recursively enumerable languages are closed under union, but not under complement or intersection, so grammar rules are naturally stated positively through a generative grammar which is a conjunction of production rules of form

\[ \text{type1} \cup \text{type2} \]

The language generated by \text{type1} is the smallest one satisfying the productions. Regular languages and recursive languages are closed under booleans, so grammar can also be written as a conjunction of constraints of the dual form

\[ \text{type1} \subseteq \text{type2} \]

The generated language is the largest one satisfying the constraints. Looking at the event calculus from this point of view, it becomes clear that we already have the makings of a formal syntax in it.

Looking at a grammar as a set of constraints liberates from the tree bias of context free grammar. Constraints do not have to be properly nested, they can also be superimposed. (There is a good computational reason for the tree bias: context free grammars are parsable in polynomial time.)

Parsing as abduction
Pragmatics differs from semantics or syntax in that it tries to derive the structure and entailments of a discourse from minimal content and rich context, using general purpose reasoning. My analysis of Thai syntax later on suggests a picture of a loose knit sequence of content words whose functions are inferred from word order and context. A pragmatic approach to syntax seems appropriate for speech; a lot indeed remains implicit and fragmentary there. Instead of writing a surface grammar for fragments, should we rather have a more explicit if abstract background grammar, plus principles to infer missing structure from the surface?

That depends on where the complexity lies: on the kind of interaction between the system and its environment. The suggested approach pays off if a system, its environment and their interaction are simpler, or more interesting, to describe separately than the result of their interaction directly. In Thai
syntax, for instance, digging deeper seems to reveal more interesting cross-linguistic morphisms than staying just on the surface.

Another example: Barber (1975) suggests representing the middle voice as a reflexive which identifies arguments in event types. Klaiman (1991) points out as a problem that the arguments so identified may not have any syntactic reflex. That is a problem only if the decomposition must stop at surface syntax.

For a third example, in the Cree sentence ni-wa:p-am-a-w-ak sisip-ak, the morphology tells that ducks are patient and subject and I am agent. Each morpheme can be written as a constraint on event types.

\[
\begin{align*}
ni &= \langle I \rangle \\
wa:p &= \text{see} \\
am &= \text{goal}\near\text{I} \\
aw &= \text{subj}\near\text{I} \\
ak &= \text{subj}\pl
\end{align*}
\]

The first constraint describes an event type which involves the first person. The second one describes a seeing event. The third one fits an event type which is directed to an object near but distinct from first person, the fourth to one whose subject is that type. The last one is true of an event type whose subject is plural.

Now the parsing problem is to find an event type which satisfies these constraints. It is clear that it must be a complex event type, for the two subject constraints cannot be true of the same event type. The smallest solution is the event type I see \pl duck where I am the agent and the ducks are subject and patient. Note that the different constraints pertain to different subevents of the solution. It is not necessary to decide on a unique surface or underlying analysis, if there is more than one solution of the equations that fit the facts. Different speakers or generations can have different theories, whose differences only surface in a few critical forms if at all.

In more complex cases the subevents which satisfy the constraints need not be disjoint, but superimposed. What we have here is a variant of the idea of simultaneous description of a sentence on several strata or dimensions characteristic of unification grammar. No surprise, for the event calculus supports unification (meet of event types containing variables). Dahlstrom’s (1991) treatment of Cree morphology implements the same basic idea in terms of LFG constraint equations.

**Grammatical types**

Grammatical types, for instance traditional parts of speech, can be classified in event calculus categorial grammar style starting from two Boolean types e and b for events and objects, or why not sentences s and nouns n or truth values t or 2 and entities e. We get the usual development of functional types (van Benthem 1986:??). The semantic type I and the syntactic type \(\emptyset^*\) are identities of dual monoids (relation algebra composition and regular algebra concatenation).

A major problem with ordinary categorial grammar is that its types are too fine. One traditional category corresponds to an entire family of categorial ones. Booleans and variables over types allow generalising more freely than standard categorial grammar. The direction of the slash does not affect the definitions below, only word order.

The same few simple categorial distinctions are hidden under a lot of traditional grammatical terminology. A denominal noun affix is an adjective, a denominal verb affix is a transitive verb and a deverbal verb affix is an auxiliary is an adverb, as types go.

<p>| s | e | t | event, sentence | en rain |
| n | b | e | object, noun | en rain |
| n\s | intransitive verb, denominal verb | de regen – regnen |
| (-s\s)n | | |
| n\n | a | a1 (\cap) n | adjective, denominal noun | klein, -chen |</p>
<table>
<thead>
<tr>
<th>p/n</th>
<th>v/n</th>
<th>n/a</th>
<th>v/a</th>
<th>p/s</th>
<th>s/s</th>
<th>n/s</th>
<th>s/s</th>
<th>p/s</th>
<th>v/(n\n)</th>
<th>(n\n)v</th>
</tr>
</thead>
<tbody>
<tr>
<td>preposition, case, denominal adverb</td>
<td>complemented noun, deverbal noun</td>
<td>denominal adjective</td>
<td>deverbal adjective, participle</td>
<td>subordinating conjunction</td>
<td>coordinating conjunction</td>
<td>Complementiser</td>
<td>coordinating conjunction</td>
<td>subordinating conjunction</td>
<td>transitivity, causative</td>
<td>detransitiviser, reflexive, (anti)passive</td>
</tr>
</tbody>
</table>

Table 10

If x is not y, x is the complement of x'y. x'x is an adjunct or free modifier of x. Adjuncts are idempotent under concatenation (composition) so they can be iterated freely: a = aa = n'n.n'n = n'n = a'. In particular, an adjunct of type x'x is an idempotent of its category x so that x'x.x = x.

The category v of verbs is not available in standard categorial grammar. Given Booleans and variables it can be approximated as (~sv)v 'a non-noun which can form a sentence alone or with a complement'. Whether this excludes anything depends on type inference. For instance, in hit hard, hit is a verb because it can form a sentence alone, so it is of category s = ∅v but hard is not a verb if it is of the type s. What about may in it may (rain)? If its category is v?v then it is an adverb and verb at once, i.e. an auxiliary.

Chomsky’s fourfield of categories n, v, a, p forms another Klein four group.

The third column shows a corresponding relational identity. An adjective can be represented as a relation join with a noun. If both adjective and noun are absolute (monadic), we get an intersective adjective. A difference between adjectives and nouns is that nouns are monadic more often.

This concludes the chapter on conceptual tools. On to TMAD.

Aspect

Aspect types are (types of) event types, defined by regular schemata, and used to classify phrases according to aspectual behavior. As far as I am concerned, aspect types can classify expressions of any kind from verbs to short stories. Practically all parts of speech may affect aspect type.

55What aspect types are worth distinguishing for a given language depends on the grammatical means available in the language. Phrases are not assigned to aspect types by fiat (i.e. there are few rules specifically saying that a verb belongs to a given lexical aspect type), rather, the aspect type is inferred from the inherent semantics of the phrase, its grammatical behavior and the context at hand. Intuitions about the aspect type of a phrase, say, a verb, are influenced by
images of prototypical uses of the verb, and may be refined by bringing up alternative scenarios where the verb is at home. Aspect type is just a projection of the compositional structure of expressions in the temporal dimension. For instance, *paint* is vague between activity and accomplishment, because by applying paint one can both affect and effect things (*paint a fence/picture*). *Watch TV* is an activity but *watch a TV program* an accomplishment.

The list of aspect types below is not exhaustive, for the simple reason that there is no exhaustive list of aspect types. Any regular expression on events is an aspect type. Aspect types do not form a taxonomy of mutually exclusive and jointly exhaustive classes either, they can nest and intersect as freely as regular expression languages do. Still, certain simple aspect types are typologically most common, and deserve most attention.

For brevity of expression, I represent the commonest aspect types by sorted variables a,b,c,d,o,m,p,q,r,s, which thus imply aspect restrictions on their values.

**Definitions**

What is a tense and what is an aspect? By a largely Anglo-Saxon tradition, tense orders events in time, in particular, relates them to a deictic or indexical *utterance time* or to a relative or anaphoric *reference time*, while aspect relates events to their parts or phases (Sweet 1900, Holt 1943, Jakobson 1957, Comrie 1976, Lyons 1977, Lapolla/Van Valin 1997:40). Thus Sweet (1900 [1955:101]): ‘aspects involve distinctions of time independent of any reference to past, present or future’. For Comrie (1976:3) ‘Aspects are different ways of viewing the internal temporal constituency of a situation’ (similarly Smith 1991:xvi). Roman Jakobson defines aspect negatively as characterising “the narrated event itself without involving its participants and without reference to the speech event” (Jakobson 1957:4). For Frawley (1992), aspect is ‘the nontemporal, internal contour of an event.’


According to this tradition, aspect (Russian *vid*) is "Gesichtspunkt, unter dem ein Vorgang betrachtet wird" Porzig (1927:52), while ‘Aktionsart ist, im Gegensatz zu Zeitstufe, die Art und Weise, wie die Handlung des Verbums vor sich geht’ (Brugmann 1904:493). However, already Streitberg (1891) and Leskien (1909) gloss over the distinction (Bache 1985). Johanson (1998:§11.7) traces the conflations back to Curtius (1846).

For many authors Aktionsart means lexical or derivational aspect (Lyons 1977:705-706). Some slavic aspectologists classify Aktionsarten (*sposoby dejstvija*) by morphology (Cohen 1989:37). For some, Aktionsart is a ‘combinatory variant’ or use of a (grammatical) aspect, i.e. an occasional meaning created by the ‘sum of all the elements which contribute to a particular interpretation of the basically invariant meaning’ (McCoard 1978:142). Among traditional Aktionsart distinctions are punctual vs. durative56, dynamic vs. stative, telic (resultative) vs. atelic (irresultative), ingressive vs. terminative, semelfactive vs. iterative and habitual vs. non-habitual (Bache 1985:13).

As Frawley (1992) sums it up,

- the literature on aspect frequently draws a distinction between two kinds of computation of event structure: those that derive from modification of the event proper, called *Aktionsart* (’kind of action’) or *lexical aspect*, and those that are a function of a perspectival change on an event as induced by discourse structure and information flow. There is little agreement on the proper terminology here, though see Bybee (1985) and Brinton (1988), and it is not always clear that this distinction can be drawn consistently (Comrie 1976).

By and large, aspect-Aktionsart distinctions involve degree of grammaticalisation and indexicality (Maslov 1959:160). Convictions may vary with language: those dealing with grammaticalised finite aspects/tenses (perfective/imperfective oppositions: Romance, South slavic, German) appreciate the dichotomy (Bertinetto/Delfitto 1998), those without them (English, Nordic, Russian, Arabic) may play it down. Some authors concede that aspect and actionality distinctions are ultimately based on the same or similar ontological distinctions or semantic primes (Lyons 1977:706, Bertinetto/Delfitto 1998:$4.2).

---

56 This traditional contrast is vague between *closed/open* and *point/region* (Cohen 1989:73-74). Cf. section on aspect features.
Others (Johanson 1998) specifically deny this. The first camp are open to aspect composition, the second camp go for two-level theories.

The aspect-Aktionsart distinction is not a primitive opposition in the present calculus, it but can be characterised (see section below on aspect as point of view).

Some writers make a terminological distinction between event internal aspect and sequential \textit{phase} (Joos 1968:138-146, Cattell 1969:120-123, Mourelatos 1981:195fn) and others between indexical tense and infinitival \textit{taxis} (Jakobson 1957).

To sum up, the tense-aspect-Aktionsart distinctions play on three logically independent but typologically related criteria: (i) temporal order vs. event structure, (ii) finiteness (absolute or indexical vs. relative or bound reference), and (iii) grammar vs. lexicon.\footnote{The reasons for the correlation will become apparent. Aspects arise by abstraction from diathesis, which deals with causal (contingent, i.e. contiguity) relations. Grammaticalisation into tenses involves contextualisation, including indexical reference.}

Dahl (1985:25) points out that notional tense/aspect definitions may not make tense and aspect disjoint. This is no problem from my point of view. The calculus of event types covers both, making no sortal difference. The logical notion is event type. Tense and aspect are grammatical categories, subject to cross linguistic variation around prototypes where many criteria agree. (Bertinetto/Delfitto 1998) Given a calculus, taxonomical terminology is often more of a hindrance than help (e.g. Declerck 1997:59).

When has a language got a tense or aspect? By one definition, when marking the temporal relation explicitly is the default or obligatory, a grammatical \textit{accident} rather than a lexical option (Dahl 1985, 1998). This is admittedly vague, and probably inherently so.\footnote{See e.g. Bache (1985:25) for a controversy on whether English "has aspect".} For TMA semantics, the grammatical makeup of a tense or aspect expression is not essential. Tenses and aspects are indicated by members of most any grammatical category from both open and closed classes, verbs and their inflections, nouns and their inflections, adverbs, prepositions, conjunctions and so on. For this reason, it is essential to develop a theory which allows capturing and combining the contribution of all of them at once. Dixon (1995) lists a number of languages (Ainu, Mundari, Tunica, Hopi, Pauwari, Pirahê, Warrgamay) which don’t have anything that could be called a tense system in their grammar. All these do show an aspectual system. !Xu is said to have no grammatical marking for tense or aspect; but it too has a set of temporal adverbs (Snyman 1970).

It is a feature of my calculus that the difference between verbs, aspects, tenses, and temporal adverbials is only a grammatical one, they all denote the same sort of thing. A consequence of this is that not only verbs, but adverbials too, may exhibit aspect. Similarly, nothing crucial hangs on the decision whether a given form is a tense or an aspect or perhaps both. This also avoids concentrating too exclusively on verbs and their inflections. Chung/Timberlake (1985) show that TMA devices use a wide range of structural means (verbs, adverbs, clitics and affixes). Not all languages have grammatical tenses (Bybee et al. 1994:119). Tenses are optional in some languages (Comrie 1985:103). Tenses and temporal adverbials are complementary in some languages (Comrie 1985:31). What are temporal adverbials in some languages occur as bound morphemes in others (Comrie 1985:18).

Surely there are interesting cross-linguistic statistical and developmental universals to be found. Nominal reference is largely independent of TMA, which is one sense in which tense and aspect specifically concern verbs (Comrie 1985, Chung/Timberlake 1985, Langacker 1987:189). It is an old observation that languages tend to follow developmental paths where new forms to come in as compositional phrases, get grammaticalised into affixes, and die out as lexicalised inflections ready to enter a new cycle. The criteria of obligatoriness and bound morphology are two sides of the same grammaticalisation coin (Comrie 1985:10). There are interesting regularities concerning the grammaticalisation of TMA notions (Dahl 1985, Bybee 1991, Bybee et al. 1994, Lindstedt 1996, Leinonen 1996), many of which can be explicated if not explained in a formal semantics.

The formalism of this book is an \textit{event calculus}, a formal language whose terms denote \textit{events}. \textit{Event} normally refers to happenings rather than states of affairs. I use it here to cover (courses of) events, episodes, situations, states, occasions, even times. Each candidate for a catchall term has its own aspectual type. Given the duality of dynamic events and static situations, most choices are awkward for one side or the other. On the plus side, \textit{event} is both everyday and short.

Historical courses of events like \textit{Caesar's murder or the life of Jesus} are complex closed event \textit{tokens} including many others, love, hate, intrigue, suffering and death. A generic event \textit{type} like \textit{murder} has common structure: victim, perpetrator, a place and time, but no specific scene or date. A \textit{situation} in my...
usage is a complex open event (type or token) of no specific duration; an occasion a bounded situation which defines the current resolution.\footnote{Bybee et al. (1994) distinguish repetitive action as iteration on the same occasion while habitual action is iteration between different occasions. A chain smoker speaks repeatedly, not just habitually.}

\textbf{Aktionsart}

In this section, a develop a taxonomy of event types.\footnote{I use Aktionsart here as a synonym for \textit{lexical aspect type}. Terminology is discussed in the section on definitions.}
The main dichotomy in aspect types is between open and closed event types. An open event type \textit{a} (for activity\footnote{It might be better to reserve the term activity for agentive processes. However, I bow to tradition and use it a cover term for open events (other than states).}) is cumulative (Quine 1960, Krifka 1987) or summative (Löbner 1990), i.e. closed under arbitrary joins. Open event types take durative adverbials (for \textit{t}) and are inceptive with bounding adverbials (\textit{in/by} \textit{t}). They can stop or continue or resume (Heinämäki 1974:10).

\begin{equation}
\text{if } e \subseteq a \text{ then } \bigcup e \subseteq a
\end{equation}

In particular, then, open event types are closed under join and concatenation, i.e. \textit{a} $\cup$ \textit{a} $\subseteq$ \textit{a}, \textit{a} $\cap$ \textit{a} $\subseteq$ \textit{a}, and \textit{a}$^*$ $=$ \textit{a}. The last property shows that open events are noncounting languages, or aperiodic monoids (McNaughton/Papert 1971, Pin 1997). The open/closed distinction has been recognised since Aristotle as an instance of the \textit{divisible/indivisible} or \textit{count/noncount} distinction (Verkuyl 1972, Gabbay and Moravcsik 1973, 1980, Mourelatos 1978, Bach 1980, Hoepelman and Rohrer 1980, Bennett 1981, Carlson 1981, Link 1983, Krifka 1987, Langacker 1987, Frawley 1992:331).

Open event types are structurally similar to noncount (mass or plural) nouns, i.e. they are \textit{divisible} and \textit{amorphous} in the same restricted sense. This is reflected in deverbal nouns from open verbs: \textit{work} or \textit{rain} is a noncount noun. Open events satisfy the characteristic axiom (Aristotle’s principle) that the present (progressive) implies the perfect: one who \textit{is Ving has Ved}. Also one who \textit{stops Ving has Ved}, while one who \textit{almost Vs} is not \textit{Ving} (Johnson 1998). Relative frequency adverbs \textit{continually, occasionally, frequently} produce open event types out of open event types..

Many aspectologists (e.g. Pertinetto/Delfitto 1994) distinguish \textit{repetitive} action as iteration on the same occasion while \textit{habitual} action is iteration between different occasions. A chain smoker speaks repeatedly, not just habitually.

\textbf{States}

A \textit{s} is a simple open event. A simple (or \textit{pure}) state is atomless in time and atomary in type. It is fully \textit{homogeneous} or \textit{homeomerous} in that all temporal and logical parts of it are members of it, i.e. it is an atom of the event type algebra (\textit{no other} event type is entailed by it).

\begin{equation}
\textit{s} = \text{in } \textit{s} = \text{of } \textit{s}
\end{equation}


States are analogous to abstract or mass terms. The algebra of a state is a complete Boolean algebra. Its topology is continuous relative to the assumed topology of time.

Given that \text{in } \textit{x} \text{ of } \textit{e} denotes the event type of arbitrary parts of an event \textit{e}, pure states satisfy

\begin{equation}
\textit{s} = \text{in } \textit{x} \text{ of } \textit{s}
\end{equation}

This entails that the progressive, if defined by \text{in } \textit{x} \text{ of } \textit{e}, will be vacuous when applied to simple states. For instance, \textit{pest} entails \textit{animal} and \textit{harmful}.

The English progressive excludes simple states because they have no associated process to be in (Vlach 1993:242). \textit{He was being a pest} shows \textit{be a pest} is not a simple state here (there is something one \textit{does},...
to be a pes. A state in the simple tenses implies the state actually holds at the reference time (whatever the reference time). Since points are nothing but events without proper parts, it follows that simple states are true and false pointwise (Galton 1984:15).

Call an event type timeless if it is two valued (denotes the unit event or the empty event). A timeless event is constant relative to time. Examples of timeless event types are eternal truths like one plus one is two, boys are boys and que será, será and temporally definite ones like It always rains in London or Christ died for our sins. (Rescher and Urquhart 1971:25-6).

There are also events that are independent of time in the weaker sense of not depending on times other than when they hold. Events that are independent of time in this sense need not be eternal. They can begin and end, they just don’t have ‘anything to do with time’. ‘Being a function of time’ here not only means that e varies with time, i.e. is true and false at different times, but that its occurrence at one time depends on what happens at other times. Simple states are timeless because they do not depend on a comparison between states of affairs at different times for their verification (Frawley 1992, Santos 1996). They can thus be predicated of times of any duration. Examples are round, large, red, and other geometric and qualitative properties that can be verified from a still image (Rescher and Urquhart 1971:23, Langacker 1987:220ff). Many qualities are orthogonal to time in this sense. In want of a better term, call such states atemporal. There are temporal qualities, for instance age.

Simple states are not agentive, because agency implies action, hence activity. They fail agentivity tests like force/persuade, the imperative, deliberately/carefully, and do anaphora (Lakoff 1965, Heinämäki 1974:9, Dowty 1979, Smith 1991:42, Frawley 1992:146ff). Being static, states have inertia: they continue to hold by default until something happens to cancel them (Dowty 1986:51). They do not consume energy (Comrie 1976, Nedjalkov 1988). All such ascriptions pertain to the essence of the state, not its causes. That star is bright denotes the effect the luminosity of that star is high, not the cause that star emits a lot of radiation.

Aristotle (Cat.8b-9a, Met. 1022b) introduces a distinction between temporary states (skhesis, diathesis) like ill, permanent states (hexis) like learned, and capacities (dynamis) like hard. The classification shows up in many languages, and is worth registering as follows.

Some states are temporary, i.e. typically bounded by their opposites: he is awake/asleep, he sits/stands/lies, one goes in and out of them (Carlson 1977, Smith 1991:38) Following Galton (1984:58) and Santos (1996), I call such conditions temporary states. Portuguese uses the auxiliary ser ‘be’ for permanent states (qualities and habits), and estar, etymologically ‘stand’ for temporary states (conditions).65 Permanent states include timeless states and capacities.

What is the representation of temporary state in our calculus? Extensionally, a maximal temporary state is a state bounded by its opposites, i.e. a cycle ¬s s¬s. Any factor of such a temporary state is also a temporary state, i.e. any event of type s: ¬s s¬s. Intensionally, we want to account for typical: a typically temporary state typically ends, not necessarily in every instance. Someone can be ill and never get well, but everyone cannot: the average is by definition normal. The outcome: we may characterise temporary state by the formula gen prog pf e: a state which as a rule happens in cycles.

Generic states (habits or dispositions) summarise states of affairs through longer periods, from which follows that they need time to be verified (Smith 1991:39). Example: smokes, is reliable. Predicating generic states of very short times seems awkward (Kucera 1981:184-185). This shows that they have coarse granularity. Simple and generic states are (relatively) permanent or stable (Santos 1996, Nedjalkov 1988). Generic states have modal and counterfactual import. The distinction between habits and dispositions will be studied more closely below.

A dynamic state is vague between a simple state, a temporary state, and a process maintaining a state (e.g. a position, a posture, and maintaining a posture). Stand is a prime example: a building stands in a simple state, movable objects stand or are standing in a temporary state, and a person is standing in a dynamic state. A dynamic state can only be verified by looking at a neighborhood of a point (one

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62Cf. English progressive He was being helpful ‘He was acting helpful’, Portuguese Perfeito estava/* agradavel ‘He was acting/acted nicely’, French passé simple il voulait/voulut s’enfuir ‘He wanted/tried to run away’. Also be obnoxious/quiet/a hero (Lakoff 1970, Lees 1971, Dowty 1979:114, Smith 1991:84).

63Having lost the Latin distinctions, Portuguese has no real posture verbs like English. Stand is variously translated by estar ‘be (temporarily)’, estar de pé ‘be on one’s feet’, and ficar ‘stop, not move’.

64The modern sense of disposition is closer to Aristotle's dynamis, while Aristotle's diathesis is a temporary state.
cannot tell for sure that an object is stationary from a still picture, G.Carlson 1977a:428). This does not prevent it from holding as a simple state at a point with the right kind of neighborhood. (An event type can entail other events without denoting them.) A dynamic state (state of rest like stand or float) can only be verified at an interval, although the interval can become arbitrarily small. This distinguishes dynamic states from simple states, which are timeless true at points.

\[ d = \text{Up} \]

The process of maintaining a state can be described as the limit of a series of small changes between the steady state and its complement. The appositeness of this analysis is seen in the trembling associated with difficulty of maintaining a posture. When resolution is decreased, a dynamic state becomes an oscillation of small adjustments around an equilibrium. Often (but not exclusively) the distinction correlates with the type of subject; animate (agentive) subjects allow the dynamic reading, inanimate objects the stative one. Examples: posture verbs stand, sit, lie, hang, hold, keep (Dowty 1979:173ff). I will return to dynamic states in the section on counterfactuals.

The interesting thing about dynamic states is that the result state is continuous and simultaneous with a continuous process. The imperfective can denote the preparatory stage or progress of the maintaining process, the perfective the acquisition or affirmation of the result state, and the perfect the result state. For instance hold in the imperfective means ‘try to get/keep a hold’, in the perfective ‘manage to get/keep a hold’. Simple and perfective aspect can denote the same event for dynamic event types: sit, stand, feel, hurt, think, hope. Examples: My feet hurt/are hurting. She thinks, or thinks she is thinking about her, as Paul reads. – I’m not sure I know fully what you are suggesting. – I suggest nothing immediate. (Bache 1985:230 Temporary and dynamic state are the Aktionsarten of progressive aspect. Holding a plan is a dynamic state, hence future progressive is one.

**Events**

Closed events are dual to open ones. An atomic (singular closed) event type (closed, bounded and simply connected) event type is is nondurative, noncumulative, indivisible, or integrative (Löbner 1990), i.e. it cannot be continued, summed or divided, only repeated. It is really the notion of a singular count event that is involved here. For them, the Boolean sum \( b + b \) or the concatenation \( bb \) is not of type \( b \) (Galton 1984:103, Krifka 1987):

\[ b + b \cap b = \emptyset \]

This property allows nesting, i.e. vagueness about boundaries as in \( \neg(s(ss)) \). The main thing is that there is numerically just one event of type \( b \) there. Closed sets in general are closed under finite joins, while for instance closed and connected sets are not. The part algebra of an atomic closed event type is the trivial Boolean algebra. Its relative topology is the indiscrete topology. Atomic closed event types are analogous to singular count nouns. Their iterations are analogous to plural count nouns, whose algebra is an atomic Boolean algebra and which are again open in a discrete topology, see below.

Atomic closed event types have a temporal profile (Hirtle 1975:§3.4, Langacker 1987:244, Löbner 1988:184), a beginning, middle and end (Aristotle), so the sequence of two such events in a row just has not got that same profile. Closed events satisfy Aristotle’s movement principle: one who is Ving has not (yet) Ved. One who stops Ving may not have Ved. One who almost Vs may already be Ving (Smith 1991, Johanson 1998).

**Change**

A simple change \( c \) is a filter of nested half closed sequences of an open event and its complement (Wright 1963, Frawley 1992), converging on, but never coincident with the vanishing period (point) of change in between. For as Aristotle (Ar.Phys. VI.8) argues, change (as well as rest) always takes time, because it includes its boundaries, and there are two of them. At the same time, simple change has no minimum extent.

\[ c = \neg(aa) \]

The point of change is covered by one of the complement states - that is what it means for states to be complementary. For instance, if a house is built, in the beginning there is no house, at the end there is one, and in the middle there is an unfinished house - but really, there is no house until there is one. Thus the event type \( \neg(aa) \) does not only describe instantaneous change (but it can describe one). A
change is closed, because \( \text{cc} = \neg \text{aa} \neg \text{aa} \) is not of type \( \neg \text{aa} \). On the other hand, change can be (improperly) nested, i.e.

\[ \text{c} = \neg \text{aca} \]

which entails \( \text{c} = \neg \text{aa} \text{a} \). Changes can be simple/atomic (\( \text{a} \) is a state \( \text{s} \)) or complex/extended (\( \text{a} \) has proper parts). Half closed event types exhibit an event/result ambiguity with \( \text{for T and again} \) (The sheriff jailed Robin Hood for years/again).

A change means that a certain open event type \( \text{a} \) becomes true, so we may write \( \text{become a} \) for \( \neg \text{aa} \). The denial of become \( \text{a} \) is stay \( \text{a} \) i.e. \( \text{aa} \). I define become here in terms of the concatenation operator. Dowty (1979:143ff) takes become as a primitive but finds that it is not sufficient alone for defining noncomplemental changes like \( \text{go from the post office to the bank} \). He notes that things would be simpler taking concatenation (von Wright’s \( \text{T} \)) as the primitive, but is reluctant to do so as become seems a more natural linguistic primitive to him. Instead, he adds Cresswell’s (1977) and as a second primitive and writes \( \text{from the post office to the bank} \) as become \( \neg \text{post} \) and become bank, which equals \( \text{post} (\neg \text{post} \neg \text{bank}) \).\(^6\)

Ryle (1949:149), attributing the insight to Aristotle, distinguishes achievements (‘success words’ or ‘got it words’) from activity or process or task words (‘try words’). The contrast between Ryle’s achievements and his activities, processes and tasks is exemplified by kick/score, treat/heal, hunt/find, clutch/hold fast, listen/hear, look/see, travel/arrive.

An interesting point is that Ryle’s achievement words include both (more or less) sudden climaxes and protracted proceedings, i.e. both gettings and keepings. They include win, unearth, find, cure, convince, prove, cheat, unlock, safeguard, and conceal, but also keep a secret, hold enemy at bay, retain the lead. Both describing a hawk and keeping it in view are sorts of success for Ryle. This is a telicity (resultativity) distinction. A change or an absence of change is resultative because it ends in a state complementary to the one it starts with or would have ended with. A causative event type is resultative if it causes or prevents a change. Ryle’s point here is that both closed and open events can be resultative. Let us have a closer look at the latter.

**Absence of change**

Absence of change, the event type \( \text{aa} \) of continued open event could be called with Aristotle rest, or permanence, or \( \text{continuative} \) event type (cf continue in the section on phasal verbs below).

Permanences are extended: Stay entails stay for some time. Poutsma (1921:31) has a list of continuative event types, including those formed with aspectualiser \( \text{on: read on, go on, keep on} \). Absence of change is open: closed under arbitrary joins and finite meets.

From this one might expect to find absence of change exclusively imperfective. Yet cross-linguistically, verbs for remaining are perfective on a state of affairs when they indicate the absence of a change at or for a definite time. In Bulgarian, phasal verbs for stopping, staying, keeping and continuing are perfective (Lindstedt 1985:180). In Finnish, there are two different verbs, perfective \( \text{jäädä} \) ‘get stuck, fall, be left behind, get off, remain’ taking goal complements and result state time adverbials, and imperfective \( \text{pysyä} \) stay in place taking location complements and durative time adverbials. \( \text{jäädä} \) means ‘not continue to move, stop, pysyä means ‘continue to not move, not start’. In practice, the two are often interchangeable. Compare

\begin{equation}
\text{Jäin huoneeseeni koko päiväksi. ‘I remained in my room for the whole day.’}
\text{Pysyin huoneessani koko päivän. ‘I stayed in my room all day.’}
\end{equation}

But there is a difference as to when I did it: in the morning, or throughout the day:

\begin{equation}
\text{Tänään (=tänä aamuna) jäin huoneeseeni koko päiväksi. ‘Today (=this morning) I remained in my room for the whole day.’}
\text{Tänään (*tänä aamuna) pysyin huoneessani koko päivän. ‘Today (*this morning) I stayed in my room all day.’}
\end{equation}

The following example is revealingly ambiguous:

\begin{equation}
\text{Mies jäi junasta asemalle. ‘The man left the train at the station/the train left the man at the station.’}
\end{equation}

\(^6\) This is not equivalent to post.bank nor to post<bank> for the former requires the post and the bank to be adjacent, while the latter allows any number of back and forth trips between the post and the bank between the end points. Both of these accept go from London to London.
The first reading says the man arrived by train at the station. It can be symbolised as \( \text{man on train} \land \neg \text{train at station} \). The subevents are The man was on the train, the train arrived at the station, the train left the station. The second reading says the man missed the train. It is the denial of ‘The man took the train at the station’, symbolised by \( \text{man at station} \land \neg \text{train at station} \). The subevents are The man was at the station, the train arrived at the station, the man left the station.

The curious thing is that the Finnish sentence portrays the man as ‘moving’ from the train (\( \text{junasta} \) ‘from the train’) to the station (\( \text{asemalle} \) ‘to the station’), while in actual fact he fails to make the opposite move from the station to the train. The assertion side of the case assignment is right: at the final state, the man is at the station and not on the train, in conformity with the cases. It is the presupposition side that fails, for the man was at the station and not on the train already at the initial state.

Tommola (1986) observes that Finnish resultative object case alternation appears even in permanences like

Simonides kantoi aina kaiken/kaikeaa mukanaan. ‘Simonides always took/carried everything with him.’ \( \neg (\text{carry} \land t) \land \text{carry} \land t \)
Antti piti hevosen jalkaa/jalan paikoillaan. ‘Antti tried/managed to hold the horse’s leg in place.’ \( \neg (\text{hold} \land t) \land \text{hold} \land t \).

Perfective permanence presents a problem only if we define resultativity through actual noncontextual (lexical) change. Looking at the instances more closely, it appears that the resultative total object form here indicates permanence at a point or through a time. When the object is total, an adverb of time is implied. Simonides carried everything along always when he left or all through his life, Antti held the leg in place until the operation was done. Given that the time \( t \) is future relative to the initial state \( \neg (\text{hold} \land t) \), this means that the initial state is in effect expected state: the hoof was going to budge at \( t \), but it did not.

This insight connects absence of change to branching future. The man’s plan was to get on the train. The actual course taken by the events causes a change from the expected future (the man was (going) to be on the train and not at the station) to the actual present (the man is at the station and not on the train). This step is not purely temporal (future), but counterfactual (past future): At the initial state, the man was to be on the train, at the final state, he was not (Lindstedt 1985:214). Although the facts do not change, their likelihoods do: at the initial state, the final state is not likely or at least not certain, at the final state, it is. Illustration:
The diagram can be read in terms of classical kinetics. In distance per time coordinates, rest is traced by the constant horizontal line, and steady motion by the straight diagonal line. Starting and stopping are mapped by curved lines where velocity changes. Continuation (constant velocity) is described by straightness of line. Rotating the right half plane 45 degrees clockwise we can visualise the situation where a straight line passes from rest to motion, while the absence of motion traces a curved path. As physics tells us, all change is relative to context, the system of coordinates. In terms of classical dynamics, if the force field changes around the origin, a force is present in the absence (cancellation) of expected acceleration. Opposition to change becomes permanence.

The verb jäädä 'remain' is the passive of causative jättää 'leave', which makes the above picture more concrete. Although the object left behind does not change position relative to its own coordinate system, the subject leaving it behind does, so relative to the coordinate system of the subject, the object does change position.

A prediction of this counterfactual analysis is that perfective permanence appears at genuine branching points in the tree of possibility. I (perfectively) stay at home at those points where I was supposed to leave home but did not (Ar. Phys. 226b14-15). Those are the points at which I cause it that I go on being at home by preventing an alternative course of events. Though there is no change in actual fact, there is a change in possibilities (Heinämäki 1974:182).

In Portuguese, the same verb ficar means 'stop, remain' and 'get, become', e.g. ficou ali 'he stopped/got/remained there', formally <s. In Swedish too bli is 'become/remain'. It seems initially paradoxical that one verb can denote apparently contradictory things (change and its negation), but really this is a simpler vague event type. The (final state) is the same, only the presupposition (initial state) is unspecified. Become and remain and their negations form another square of opposites (Löbner 1990:89).

In general, verbs be, become, remain, their causatives make, cause, have, keep, media or passives get, as well as the corresponding verbs of position and motion stand, sit, lie, come, go, stay, take, bring, hold form a central locus of neutralisation and metonymy for TMAD systems.

**Processes**

A process (Vendler’s activity) is a state of change (Galton 1984), (the limit of an) iteration of some (complex) event.

\[ p = e^+ \]

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**66**It might make good sense to use activity of agentive processes in particular (e.g. rain would be a process rather than activity).
Here ε is not p itself (that defines states). The resolution of p need not be unique (Parsons 1990:184). A process is open and extended (Bennett 1977,1981:18), because \( p = e^* = (e^*)^+ = p^+ \). One of Vendler’s criteria for activities was the Aristotelian entailment that the progressive implies the perfect, i.e. he is walking entails he has walked. Although this entailment may not be strictly valid because of the granularity of some processes (having walked may require a certain number of steps, and one can be in the middle of them before one is through them), it is true for coarser resolutions. As in Carlson (1981), I see no need to add a subinterval or homogeneity principle qualified by granularity (Link 1998:203,303). One seems to already follow from the upward closure principle just given.

Whether a process appears dynamic or static is relative to scale or resolution (Langacker 1982:269). A process which oscillates around a steady state involves a series of local changes without producing a global change; it is dynamic in the small but static in the large. It can be smooth, continuous and monotone or have complicated discrete internal structure. Lose energy is also a process.

A process can be an oscillation, an undirected iteration of a change or cycle. (Recall that for states s, ss \( \subseteq s \)).

\[
p = (\sim ss^{-}s)^+ = (\sim ss)^+ s = \sim s(s^{-}s)^+
\]

An oscillation is irresultative (it produces no overall change). Such states of change have and have not got a temporal profile (Jakobson 1957) depending on granularity. Unlike states, a process is of a different event type than its complement, the absence of a process. Unlike events, a process can go on, it has no built in lifespan (it is periodic. Rozenberg and Salomaa 1997). In a small enough scale, an activity entails change; in a large enough scale, it entails permanence. In the absence of comparative change, there is no limit to approach or reach. In Russian, many nondirected process verbs lack perfective pairs, e.g. (Johanson 1998)

For iteration of discrete closed events (pf e)\( ^* \) or pf\( ^* \) e the names series (Santos 1996) seems apt. If processes in general are noncount, then a series is specifically the plural of an event type in that it denotes a set of countable and separable individual events. The Boolean algebra of a series is a nontrivial atomic one. Its topology is the discrete topology. Serial event types are usually glossed by ‘one by one’, ‘one after another’. Series is a special case of plural (or distributive) event type, consisting of a plurality of discrete events of the same type (not necessarily successive but, for instance, spatially distributed). Some languages, like Navajo, have distributive or plural aspectualisers.

Or a process can imply progress, directed gradual comparative change where there is a stepwise but for a large enough granularity monotone increase or decrease along some comparative property (scale).\(^6\) It is important to distinguish relative or comparative change such as become larger from absolute or positive change such as become large. It is easy to prove that relative change is open while absolute change (change to a specified value) is closed (one cannot become large twice in a row without becoming small in between, Dowty 1979:168-169). A comparative change produces a global change relative to any given bounded period of time (is perfective), while at the same time, it also satisfies closure under joins, so it is imperfective. Accomplishments denote comparative changes accumulating into an overall absolute change. Progress or gradual adverbs gradually, little by little single out comparative changes (Bertinetto/Delfitto 1998).

Continuous change can be described as the limit of a series of changes where unit of resolution tends to zero. Continuous change is homogeneous (closed under open subperiods). Still, although arbitrarily short, continuous change is still extended (it takes at least two data points to detect it, Ar. Phys 239a20ff).

And then of course there are complex processes, for instance building might be described by a complex regular expression in the style of (hammer|saw|carry|use|rest|think). (Thus one can be building something without doing anything.)


I’ve done nothing for the past hour except read this damn book.

Well, actually that’s not true, there’s the two and half minutes that I went to the bathroom, and the two thirty-second periods I spent looking out the window, and all those fractions of seconds I was blinking...

\(^6\) Bennett (1981) objects to process as a term for (nonagentive) activity just because of the suggestion of progress (directed overall or average change) in it. Cf. also Quirk et al. 1985.
There are several approaches to accommodating it. One is to say that quantification over times is restricted to relevant occasions. The pauses don’t count as long as they don’t include competing activities to the reading. (It would be different if I had took up some other reading, watched TV, or been on the phone.) Another one is to say that the quantification is relative to granularity: it is enough to find a cover of the half hour with periods of reading of some reasonable granularity in each member of which it is generically true that I am reading. It is when resolution approaches the level of seconds that the universal quantification becomes false. A third one is to say that one is literally reading the book even as one blinks, because one cannot reasonably read without blinking. Reading is defined by its result, not by what one does each individual minute. A fourth one (Bennett 1981:21) is to admit that activities simply are disconnected. I think all of these explanations are correct and compatible. Compare Vlach’s (1981a,b) example

(Someone walks into a theater, points to an empty seat and asks:)

- Is someone sitting here?
- Yes and no.

A person who has left a seat temporarily has not left it permanently. She is not sitting on it for the moment, but the seat is taken for the duration of the show.

Ritchie (1979) divides English activities into two groups depending whether they appear as cycles or acquisitions in temporal clauses. In

I shouted to him after he ran.
The guests arrived after he slept.

after he ran preferably means after he ran off while he slept preferably means after he slept enough. Changing massaged him for shouted to him and left quietly for arrived changes the preferences. In general, the closure of an activity appears as acquisition when the scale is small (resolution is fine) and as a cycle when the scale is large (resolution is coarse). The interpretation is sensitive to context (the likeliest closure is chosen when a closed event type is required by the context.)

Cycles

A cycle (a momentaneous or transient event) is a change to an event and back (Klein 1994:96). A cycle is closed, but not resultative, because the final state is the same as the initial state. Cycles will have an important role in explaining the existential perfect (Lindstedt 1985:213ff).

\( a = \neg ee'e \)

Because it cannot be continued, any closed event is equivalent to a cycle of itself \( \neg bb'b \) (read: b once) but does not denote the same (the events have different parts). Cycles too can be simple or extended, with knock and hit as examples of the former, kiss and visit of the latter. Smith’s (1991:56) semelfactives are simple cycles, which shun the progressive. My definition is noncommittal about this: extended cycles like visit or kiss do allow progressive.

Cycles are sometimes called punctual (Comrie 1976:41), momentaneous (Cohen 1989:76) or semelfactive (Smith 1991) and discrete iteration of cycles frequentative. Some languages as a rule mark the frequentative/semelfactive distinction in verb morphology (Finnish, Navajo), others as a rule don’t (English). This is analogous to marking plural inflection (Jespersen 1924:210). Note that the iteration operator \( e^* \) covers a single occurrence as a special case (proper iteration is \( ee^* \)). Forms in which iteration is unmarked actually put this option to practice. Cases in point are English cycles (cough, flash, blink) and the Russian imperfective, see below.

Smith (1991:67) claims that semelfactives, unlike achievements, do not have a future progressive. While Bright star is winning the race can mean she is in the lead, The canary is flapping its wings should not (in Smith’s view) mean it is going to spread them, only that it is already moving them up and down. This may be a question of scale. You can’t tell flapping from spreading before the wings are coming down, unless you are watching a slow motion film. Canaries’ flapping of wings is not planned either. (Compare I am visiting my grandparents next weekend.)

Palmer (1987:§4.1) compares I’m writing a letter/book and finds it likely the letter is actually being written at the time of speaking, whereas the book has merely been begun. Bennett (1981:28) notes that Max was selling cars from 12:00 to 1:00 imputes higher rate of selling cars (at least one per hour) than Max was selling cars for a week. The latter can be true while the former is false. This is a case of scale.
Cycle is a minor lexical event type in many languages. English, for failing to mark number, does not distinguish between states and cycles or cycles and series (touch, sigh). It is a common event type in grammatical aspect, where cycles are produced by bounding open event types with temporal adverbials. The contrast between lexically produced resultative (half closed) event types (punctual-terminative in Ikola 1949) and grammatically produced cycles (closed event types, linear-terminative in Ikola 1949) is a major factor in the aspect-Aktionsart controversy (Johanson 1998).

Cycles shun resultative perfect. Compare I stand corrected to I stand telephoned, where the phone call leaves no dent to its target. (McCoard 1978:227, Parsons 1990:312) Or the door is locked/knocked.

**Telicity**

Are closed events telic (resultative)? A definition of resultativity is needed to answer that. In Aristotle’s definition, result is the end (suffix) of an event type, which leaves it to the event type to detail the definition in each case. For a change, the result is the final state of the change. The more surprising consequence of the definition is that the result of an open event is the event itself. Thus an open event has attained its end as soon as it has begun.

Vendler 1967:103, attributes the idea to Gilbert Ryle (1947), who refers it back to Aristotle Metaphysics 1045b:

> Since of the actions which have a limit none is an end but all are relative to the end, [they] are in movement in this way (without being already where the movement aims), this is not an action or at least not a complete one (for it is not an end); but that movement in which the end is present is an action. E.g. at the same time we are seeing and have seen, are understanding and have understood, are thinking and have thought (while it is not true that at the same time we are learning and have learnt, or are being cured and have been cured) [...] Of these processes, then, we must call the one set movements, and the other set actualities.

The test has been used by others too (Lindstedt 1985:155) to distinguish between atelic and telic verbs. Actually Aristotle is not saying that actualities have no telos, quite the opposite, they are ends in themselves.

In the Aristotelian sense, the inception of an open event is resultative. The perfect ἐτεθέλαι 'be in bloom' is resultative too, for it denotes the result of the acquisition ἁθλεῖν 'blossom' (Kühner 1896:§384.) In contrast, a cycle of an open event type is closed but not resultative in that it does not produce a change into a state different from the initial state. The only (and irreversible) result of a cycle is that it happened. (This is Galton’s 1984:§5.3 profective aspect). Smith (1991:105) claims that some languages (Chinese) give resultative and irresultative perfections separate treatment, others don’t (French).

Prototypically, an event type is resultative if it entails a change, i.e. a half closed event type. On the other hand, the existence of permanences on the one hand and cycles on the other hand establish a two-way proof of independence between change and resultativity: permanences entail no actual change but may appear resultative, while cycles entail changes but are irresultative. Yet change and resultativity do not seem unrelated. In some way, the exceptions are very special cases. The perfection of a permanence prevents a change at a specific juncture, while a cycle involves a change undone by an opposite change.

A permanence can be closed by limiting it to a specific time of expected change: \( (\text{be} \cdot \neg \text{be}) \) which captures the idea that when one manages to stay on, he wasn’t going to do so, according to some counterfactual theory \( \tau \), but is in actual fact staying now.

If we resolve the counterexamples in this way, we can keep to the simple idea that resultative or telic event types are topologically half closed, i.e. they contextually entail a one-way change:

\[ \text{telic: } \tau \rightarrow c \]

Galton (1984) suggests a definition by which an event type is irresultative if its closure coincides with the closure of its interior: \( \text{pf prog } e = \text{pf } e \). In my framework, this holds for open events and cycles, so Galton’s definition agrees with mine here.

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69 Forsyth (1970:2) finds it ‘somewhat tortuous logic’ to consider inceptions terminative. I agree with Kühner.

70 Ruipérez (1954, in Cohen 1989:80) observed that the inchoative and terminative reading of a Greek aorist depends on whether the verb is a change (closed) or not (open).
Achievements

Vendler’s class of achievements is in my terms a mixed class containing half closed events (simple changes) and closed events (cycles) in my classification, so it is defined as the disjunction:

\[ \neg \text{aa} \text{a}\]

(Mommer 1986:75, Moens 1987:57, Declerck 1997:201fn). Simple changes (if any) have no proper parts, so they should not allow an interior progressive. A traditional showcase, notice, does tend to get coerced to iteration in the progressive. Here, iteration is hardly distinguishable from incremental process:

People are noticing this stock and overlooking the other. (WSJ)
The prime minister was noticing symptoms. (LOB)
If we want to find out whether someone has been noticing what he has been reading, we are generally content to decide the question by cross-questioning him not long afterwards. (Ryle)

In Ryle’s (1949) unwitting example notice is already close to pay attention.

It seems many momentaneous achievements are in fact closed from both ends in that the result state too is bounded in duration. The awkwardness of I noticed it for a moment as a reference to the duration of resulting awareness suggests notice already has a cycle for result state, unlike recall (compare recall for a moment). Perhaps notice means ‘become aware for a moment’, not just ‘become aware’. Find is more like a change from lost to found: We found her for a moment but then she ran away again somewhere seems passable.

Arrive is similar to notice. One cannot say He is arriving/he has arrived very long before or after arrival. It seems arrive would be something of the order of \( \neg \text{there.} \text{there}\) near, which makes it a cycle of little or no duration. She came for good is fine but She arrived for good is odd (Mittwoch 1988:215). Interestingly, also Russian imperfective movement verbs with pri- ‘near’ e.g. prixdit’ come, arrive can only be iterative (Forsyth 1970:167).

Reach the top is similar. Reach is a success verb: it means manage to get, which implies you tried. Its denial not reach implies you were near but didn’t. It would be fatuous for me to say I have never reached the top of that mountain if I was never even near it. It makes sense to ask someone Did you reach the client on the phone? only if he was supposed to call. No, I didn’t reach them if I haven’t even tried is a white lie. Reach is not a simple achievement in that reach does not just mean become at, it entails an approach. Compare A message appeared on/reached the screen. In the latter, unlike the former, the message must have got there from somewhere else through a gradual approach. Conclusion: reach is of event type \( \neg \text{at.} \text{at}\) near.

These achievements are absolute (positive) changes, despite appearances. Approach, in contrast, is a relative (comparative) change: it can mean get near, get nearer or get next to something. The sense of approach in reach seems to involve the step from near to next to, i.e. the last leg from a neighborhood of a goal to contact with it. Reaching something only covers a short distance relative to the total distance traveled, and (even allowing for final deceleration), a fraction of the total time taken.

Achievements vs. accomplishments

The Vendlerian distinction between achievement and accomplishment concerns the internal structure of events (the ‘stuff in between’). The distinction between simple and complex event types is made clearly in Aristotle Eth.Nic. 1174a20-b14. Accomplishments, having parts, are complex and extended, achievements simple or at least not essentially extended (Vlach 1993:243). Granularity is involved: Dowty (1986:42-43) suggests achievements are

not only typically of shorter duration than accomplishments, but also those which we do not normally understand as entailing a sequence of sub-events, given our usual every-day criteria for identifying events named by the predicate.

Smith (1991:60) suggests that achievements differ from accomplishments by never entailing a preliminary process. I think that is wrong; some achievements do require one (e.g. reach). Achievements with a preliminary process might be called process achievements in contrast to simple achievement which do not. Process achievements like grow up or reach have no built in starting point and hence no minimum extent (the time it takes to grow up or reach adulthood depends on where one starts counting), but they do have a built in endpoint.

The difference between achievement and accomplishment is rather that an achievement happens at the last point of the process, while an accomplishment happens during it. An achievement can contract to a
point, because it has no minimum extent. In topological terms, an achievement is a system of left neighborhoods of a point (Kelley 1955). An accomplishment concerns change between contrary rather than complementary states (from dark to light, as against from dark to not dark). The difference between “instantaneous” switching on a light ~light,light and “durative” dawn dark,~(dark,Ulight),light is whether we recognise any intermediary states where it is neither dark nor light. The distinction is thus sensitive to resolution (Dowty 1986:43). Though many events usually classed as achievements do in fact have duration (Heinämaki 1974:19, Dowty 1986:42), achievements are “punctual” in a sense akin to that in which events in a narrative are punctual in Kamp’s theories: they are not interrupted by other events in a narrative.

Ryle 1949 (Dowty 1979) notes that achievements do not allow manner adverbs like attentively, studiously, vigilantly, conscientiously, pertinaciously, slowly, rapidly, systematically, haphazardly which describe the associated process. There is a connection to causativity in that the activity of bringing about the effect is such a process. One can finish accomplishments but not activities or achievements (Heinämaki 1974:11). Achievements become iterative in durative contexts like V for T, spend T V-ing, be V-ing, or stop V-ing, accomplishments need not (though they may). Mourelatos (1981:194) notes that in equals after for achievements but not so for accomplishments: I shall start/run a mile in/after ten minutes. Johanson (1998) points out that accomplishments allow a generic (unanchored) question How long does it take to V?

Another example of the distinction is go/leave: going from one place to another takes time (there are places in between to traverse) unless the places are complementary. Leaving is going away, from one place to its complement, so leaving can be contracted to a point. It need not (there may be things to do in between).

Although there are clear cases of accomplishments (agentive incremental changes like build a house or extended motion like walk from x to y) and relatively good cases of achievements (nonagentive momentaneous verbs like notice or find or touch), a sharp boundary is hard to maintain. The distinction between achievement and accomplishment is a matter of resolution. Many events can be pictured in either way by changing the resolution (as in slow or fast motion film). For this reason, it has become something of a commonplace to suspect or reject the achievement-accomplishment distinction, especially as it has relatively little work to do in English grammar (Bach 1981, 1983, 1986, Mourelatos 1981, Verkuyl 1993, Tenny 1994).

Chaput (1990) finds it useful for Russian to distinguish between true achievements (imperfective form is iterative only), inceptive achievements (imperfective denotes result state) and end-in-sight achievements (imperfective is progressive). Chaput’s true achievements are my simple changes and cycles, his inceptive achievements my acquisitions, and his end-in-sight achievements are my process achievements. The names don’t count, the crux is that the calculus can reflect those classes which get lexicalised or grammaticalised.

Accomplishments

An accomplishment is a process producing a (comparative) change, or such a change produced by a process (Bennett 1981:17, Vlach 1981, ter Meulen 1983, Mittwoch 1988:248). An accomplishment is finished when a change is reached and stopped when the process stops (Heinämaki 1974:10:11). Almost is ambiguous with accomplishments: John almost opened the door means he almost started or almost finished doing so (Smith 1991:54).

\[ m = p\{c \}

The connective here is a type meet p\{c which corresponds to token join p\{u. Type join p\{u would be too weak, for a true accomplishment entails both subevents (this is known as nondetachability: Dowty 1977, Vlach 1981, Smith 1991:50).

The characterisation does not yet express the fact that the process causes the change. (A better approximation will be given in the section on diathesis.) An accomplishment cannot in general be contracted to a point (Heinämaki 1974:11). In accomplishments like build a house or paint a picture the change is between contraries and coextensive with the process: the event includes both the process and the change (Parsons 1990:218). Thus one does not say Ada (finally) wrote the novel at 2 o’clock last night to mean Ada finished writing the novel at 2 o’clock. Only when can mean ‘during the building’ in We helped him when/before he built the house while only before can do so in We helped him when/before the house was ready. Often but not always, the change is a comparative change between two contrary states. The process continues until an absolute change to a final a state from its contradictory results:
\( m = p.c \)

There need not be a unique culmination point. Examples like *open, take off, leave, fall down* etc. (Carlson 1981) are vague depending on where the change happens, because a change happens between contrary rather than contradictory states. There is an initial and a final change to choose from:

\( m = c.p.c \)

For instance, *take off* can mean leaving ground or reaching cruising altitude. *Open* can mean ‘not closed’ or ‘wide open’. That is why a plane can be taking off both before and after it takes off, and one can be opening a door both before and after one has opened it. As acquisitions they mark an initial change: After *I fell off the cliff I kept falling* is fine. After *I fell on the ground I kept falling* is no good, because the final change is included.

Accomplishments are often complex event types. For an example, **build a house** might be instantiated in a given case as

\[(\text{hammer} \cup \text{see} \cup \text{carry} \cup \text{rest} \cup \text{plan})^+ \cap \text{house}.\text{house}\]

**Activities vs. accomplishments**

In terms of lexical makeup, two types of accomplishments can be distinguished: those which name the process and entail the change, and those which name the change and entail the process. These types could be called *process accomplishments* and *result accomplishments* respectively. Examples of process accomplishments are English manner accomplishments, *read, write, eat*. Process accomplishments appear intransitively as activities with an implied noncount object (*read, write, eat*) and participate in so-called conative prepositional constructions *read in, write at a book*. Result accomplishments include Levin’s (1989) change of state causatives like *break, crack, bend*, which are causatives of corresponding intransitive changes. The former border on accomplishments, the latter on achievements, depending on the detachability of the entailed subevent.

The former type may implicate but do not entail a definite change (T type events of Dahl 1981), say *paint the fence, lift a weight, take a bath*. Thus *paint the fence* can mean ‘apply paint to the fence’ or ‘coat the fence with paint’, *lift a weight* can mean ‘lift up’ or ‘lift higher’ or ‘lift and put back’, *take a bath* can mean getting clean or just bathing for a while.

The borderline between activities and accomplishments is as negotiable as the boundary between accomplishments and achievements. One can turn an activity into an accomplishment by setting a bound to the activity (e.g. by adding a count object or a goal complement), and turn an accomplishment into an activity by removing one (e.g. adding a noncount object or directional complement). Many English event types are vague between the two classes: *read a book, comb one’s hair*. Formally, the difference to true accomplishments is that the focus of the event can be on the process alone.

\( p \cup c: p \cap c \)

Accordingly, the perfective of a process accomplishment may just denote the closure of the process (a cycle). Process accomplishments take optional or default complements or reflexive forms (medial diathesis) and behave as activities when used intransitively: *read, eat, wash (oneself)*.

Many process accomplishments, like *cook the meat, fill the tank*, are relative or comparative changes, that is, the change can be expressed by a comparative adjective which allows degrees (*more or less done/full*), has an absolute positive or norm (like *done*); some have a maximum (*full*). The open-closed vagueness of the verb reflects vagueness about whether the change is relative (comparative) or absolute (positive) (Abusch 1986). *I cooked the meat in an hour* entails *the meat was done in an hour*, while *I filled the tank for an hour* entails *I made the tank fuller for an hour*. Tenny (1994) notes a variability in judgments between different types of accomplishments here.

There is a related diathesis distinction between *affected* and *effected object* accomplishments (Smith 1991:52). Effected object accomplishments cause a change in the object, which sets a natural boundary (Smith 1991:48) to the event, while affected object accomplishments are noncommittal about what happens to the object. Verbs of creation and destruction (instances of the *cause become* schema) *make, build, destroy, kill* are cases of the former, verbs of application and consumption (instances of the *use* schema) *paint, read, eat, use, mow lawn, comb hair* of the latter.

For instance *read* has a natural boundary at *read everything once*, but the implicature of closure is easily defeated, as one can read the same thing many times over; *feed the puppy* has a natural boundary when the puppy has had enough, but one can always feed him a little more a little later.
There are ways to make the intended sense explicit. One is to add a result clause: *eat up*. One is to make the object oblique: *eat at/of something*. A durative adverbial may force a process reading: *I wrote that report for two hours* does not imply the report is finished unlike *It took me two hours to write that report* (Smith 1991:158). A true accomplishment shuns durative adverbials: *Mary walked to school for an hour* or *We built a house for two weeks* are odd (Smith 1991:54,69). Conversely, a bound adverbial turns a process accomplishment into a closed one (an inceptive change or cycle): *John pushed the cart in two hours/It took John two hours to push the cart* (either to start pushing it, give it a push, or push it somewhere).

The activity-accomplishment distinction is a closedness distinction. The class of derived accomplishments is large in English because English uses prepositions and adverbs to establish bounds on activities. Such derived accomplishments are rare in Portuguese (Santos 1996) and other Romance languages, where English accomplishments are often unpacked into activities and/or achievements, e.g. *walk home* becomes *go home on foot* (Vinay/Darbènet 1958).

Santos (1996) claims that Portuguese does not distinguish between activities and accomplishments. An apparent closed accomplishments like *andar à Lisboa* ‘walk to Lisbon’ fails to denote the result. For instance, a resultative adjunct *chegada à Lisboa* ‘having arrived to Lisbon’, cannot be formed from the process accomplishment *andar à Lisboa* ‘walk to(wards) Lisbon’, *andada à Lisboa* ‘having walked to Lisbon’.

Examples from English, Malagasy (Travis 2000:172) and Chinese (Ritter/Rosen 2000:208). A resultative reading is implicated in each case, but it is defeasible.

- **en** I shot him (in the head/*dead), but he did not die.
- **mg** namory (past) *nahavory* (pf past) ny ankizy ny mpampianatra nefa tsy nana fotoana izy. ‘The teachers (tried to gather/gathered) the children but they ran out of time’.
- **zh** Ta *(sha-le) Zhangsan* / *ba* (obj) *Zanghsan sha-le*, keshi Zhangsan mei si. ‘He (tried to kill/killed) Zhangsan, but Zhangsan did not die.

**Acquisitions**

An *acquisition* (Santos 1996) denotes an open event (state or process) or a change producing it (Breu 1985, Sasse 1991, Seiler 1993:28, Johanson 1998), e.g. *see, hear, remember, forbid, permit, turn, fall, face, head, hide, flee*.

$q = \neg a? a$

The inception-duration relationship of an acquisition is an alternative perspective to the event-result relationship of the perfect, depending on which seems to be the ‘main thing’: if the change is the main thing, the state is its end result, if the state is the main thing, the change is its beginning. Perfective and perfect are sort of inverses here: a result state can be turned into an incipient change with the perfective, an incipient change into result state with the perfect. Nice minimal pairs are English *inceptive have* and the state perfect *got* or Greek present/perfect *ktaoamai/kektemai* ‘get/have’ and present/perfective *ekho/eskhon* ‘have/get’ (Kühner 1896.§384). Acquisitions thus denote the end effects of a causal chain, so they tend to be intransitive or nonagentive.

Since an acquisition is vague between change and its result, aspects have a field day. The imperfective denotes the preparatory process or the result state, the perfective the initial change or a cycle, the perfect the result state (Johanson 1998.§10.3.1.2). Examples from Greek (some of them actually translate into English examples of the same type): *thallo/ethela/tethela* ‘flourish/shoot out/be in bloom’, *ozo/ozesa/ozeka,ododa* ‘smell/give out a smell/be smelly’, *hegeomai/hegesamen/hegemai* ‘think/decide/be of the opinion’, *keutho/ekheusa/kekeutha* ‘lurk/hide/be hidden’, *khairo/ekhairesa/kekhareka* ‘rejoice/gladden/be glad’.

Santos (1996) observes that the result perfect of a simple acquisition is infelicitous: *I have remembered his name now or I have had an idea* are odd as immediate perfects. They are fine construed as existential (at least once) or universal (all along). The bare result perfect would be equivalent to the present: *I remember his name, I have (got) an idea*. The perfect is fine when the associated change is complex: *They have agreed/agree on the conditions and I have understood/understand mean different and are ok* (Hirtle 1975:38).

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71Smith (1991:290) claims there is a contrast in French between *Il écrit une lettre pendant une heure* ‘He wrote a letter for an hour’ (ok) and *Marie a dessiné un cercle pendant une heure* ‘Marie drew a circle for an hour’ (odd).
English allows variation between simple and perfect aspect with certain acquisitions (Crystal 1966:271, Declerck 1994:91): be hidden/hiding, I have understood/understand, I have forgotten/forget his name, I have heard/hear you are ill, he has told/tells me that you are not working hard (Hirtle 1975:38-39). An interesting case is have (got): Do you have much snow in Quebec? can mean do you generally get/have you got.

Cf. also German erkennen 'be(come) aware', erhalten 'get/have'. English progressive and Chinese imperfective zhe both produce an ambiguity between ongoing event and result readings in acquisitions (Smith 1991:116):

John was sitting in the chair.

Tianli zhong-zhe huar. ‘Flowers were (being) planted in the soil.’

**Aspect shifts**

Aspect is complicated by the existence of *aspect shifts*, or unmarked aspect alternations (Poutsma 1921:$§3.3$, Allen 1966:198, Joos 1968:114-117, Leech 1969:135, Hirtle 1967:69-84, Scheffer 1975:61-75, Carlson 1981, Mourelatos 1981:196, Zucchi 1998), also known as *aspect transitions* (Moens 1987) or *situation type shifts* (Smith 1991:36, §3.3). Instead of assuming that an individual aspect operator or tense creates a range of meanings, it is often preferable to assign the shifts or derived meanings to the event types operated on. If the shifted or derived meaning is not limited to a particular aspect type, it may be convenient to make it an optional lexical rule, or unmarked alternation. Lexical alternations of event types may go unnoticed in forms where they do not make a difference; but they become visible where an aspect operator *coerces* an event type to another one by forcing an application of an intervening unmarked aspect operator.

The difference between coercion and vagueness/ambiguity is a matter of grammatical division of labor (Zucchi 1998:350). Coercion differs from disambiguation of a vague/ambiguous form only in that the theory does not locate the disjunction in the lexical aspect type but in an unmarked aspect operator applicable to a class of forms. This is the distinction between rules and lexical entries in formal grammar theory, or type assignment and type inference in categorial grammar. The alternation can be localised in the lexicon, in a lexical rule, in a grammatical construction, or derived as an entailment or implicature from the context. It is basically a question of where disjunctions should be placed in grammar. The usual criteria are what gives best explanatory value, closest fit and smallest grammar.

What one language does not have an explicit aspect for becomes an unmarked aspect shift relative to another language. Alternatively, and possibly equivalently, they have looser definitions for lexical aspects. Many languages leave largely unmarked iteration (English), perfective (English) or progressive (German). English simple tenses are nonprogressive, which means that they are closed or generic (Curme 1931:XIX). For unmarked aspect shifts, see Lindstedt (1985:$§3.2.5$), Moens (1987); against them, see Heinämäki (1984:67), Santos (1996). This is an instance of zero morpheme controversies.

An important observation is that unmarked aspect shifts happen with unmarked forms, but appear to be blocked for morphologically marked forms. For instance, Russian unmarked imperfective aspect *chital* is open to progressive, simple, or iterated readings, but marked perfective *dochital* ‘read to the end’ is not; instead, there is a marked secondary imperfective *dochityval* ‘was reading to the end’. This observation will be taken up in the section on markedness, where it is suggested that ambiguities registered as unmarked aspect shift arise through Boolean differences of marked and unmarked aspects.

**Inceptive aspect shift**

An open event $s$ can can in principle be closed in two different ways. One can single out the half closed initial change $\neg s$, the beginning of $s$, or a closed cycle $\neg s \neg s$. Generally, both options are there, but they are not equally salient for all verbs. Though there are clear cross-linguistic correlations here, there are language particular differences as well (Johanson 1998:§10.3.1.2).
Postulating a lexical aspect type of *acquisitions* (Santos 1996) instead of a general rule of inceptive (inchoative, ingressive) aspect shift (Smith 1991:78) is motivated by the observation that the choice is lexically governed: not all open event types allow inceptive readings, at least not with the same ease (Poutsma 1921:7-23). Compare for instance acquisition *remember* to state *be in Norway* with *after* in

After I remembered his name, I remembered it for a long time
After I was in Norway, I stayed there for a long time.

*After* can mean after the recall in the former, but it tends to mean after the visit in the latter. *Once I was in Norway* would be preferred if I stayed in Norway. This may depend on scale and expectations. Partee (1984:fn31) finds *After Mary was in the hospital* ambiguous between ‘after she began to be in the hospital’ and ‘after her whole hospital stay’.

Dowty (1986:51) notes that *sit, stand* and *lie* admit the inceptive interpretation much more frequently and readily than other statives, and perhaps should be regarded as truly ambiguous between static and inceptive readings. Location and posture verbs (*sit, stand, lie, hang, hide*) are acquisitions in many languages, i.e. have disjunctive aspect type ≠seated?seated. Here, stability (liability to change) may be an essential part of the profile: posture is not enough to choose between *sit, stand, and lie*. Assuming a lexical class here is the object oriented solution to locating the event-state ambiguity. It seems preferable to the alternative proposal (Smith 1991:225-226) that English progressive has a special resultative use which only emerges in this class of verbs.

At the other extreme, Chafe (1970:1972, Hirtle 1975:92) notes that it is difficult to imagine situation where *The door has been open* could imply that the door is now open. But *open* is already a resultative, the result state of the change *open*. This seems to generalise to result states in general: the biblical sense of *I knew her last night* is rather marked in English (unlike Portuguese *conhecer* ‘meet, know’ which is an acquisition). Progressives don’t get inceptive reading either: *When Marilyn entered everyone was cheering* suggests they had started without her. Such open events are prototypically interior. *Be in Norway* may belong here.

Many apparent cases of inceptive reading do not call for any special rule. The section on ordering events revealed that temporal relations between extended events logically reduce to relations between endpoints. *John fell asleep before he knew it* makes *know* appear inceptive by sheer force of logic. *Knew* is equivalent to *noticed* here: he knew it as soon as he noticed it. The same holds of *John was asleep before he noticed it*: for he was asleep as soon as he fell asleep.

Activity verbs assume an apparent inceptive reading in *when* sentences: *When Marilyn entered everyone cheered*. Apparently, they started cheering when they saw her. Yet no inceptive shift need be involved. The *when* sentence just says some cheering occurred on Marilyn’s entry. Although it entails *everyone started cheering* the two are not equivalent; the resolution is different. *Cheered* denotes the reception in its entirety, *started cheering* its inception.

**Aspect transition network**

The following diagram, an aspect transition network of the type of the type introduced in Moens (1987) and applied in Santos (1996), maps some common aspect shifts between event types. Legend:

- **a** open event type
- **b** closed event type
- **c** change
- **m** accomplishment
- **o** cycle
- **p** process
- **q** acquisition
- **s** state
- **freq** frequentative
- **inc** inceptive
- **mom** momentaneous
- **pf** perfective
- **prog** progressive
- **res** resultative

**Table 11**

The diagram loops back from the right end to the left. Unlabeled arrows represent type subsumption (inclusion). Perfective aspect shifts into initial changes ≠ee, closures ≠ee=ée and final changes e=ée are known by many terms including inceptive/ inchoative/ ingressive, completive/ delimitative/ perdurative, and terminative/egressive respectively.
Derivation

In addition to unmarked transitions (‘null derivation’), aspect transitions are marked by derivation and suppletion. Historically, derivation (as a type of word formation) often goes back to compounding while inflection comes from periphrasis (phrasal constructions). For instance imperfectives arise both ways, from locative periphrasis and from iterative derivation.

Greek has a systematic distinction between imperfective, perfective (aorist) and perfect stems. Russian has a number of suppletive pairs or tuples of verbs that only or mainly differ in aspect. Lindstedt (1985:160) exemplifies the various meanings obtained by prefixing Bulgarian varjà ‘boil’, e.g. ‘parboil, bring to the boil, boil again, overboil, overboil slightly, boil every now and then, underboil, boil more as needed’.

There is a long grammatical tradition of enumerating and naming various lexically governed event types or Aktionsarten. It continues as the study of the meanings of aspectual prefixes in Russian aspectology, where they are known as modes of action (splosoby dejstvija, Johanson 1998) or procedural (sovershajemost’, Isachenko 1962, Forsyth 1970). Here is a combination of the lists in Comrie (1976:§2), Lyons (1977:§12.4,15.6), Bache (1985), Forsyth (1970) and Johanson (1998), with suggested formalisations.

Figure 9

<table>
<thead>
<tr>
<th>open</th>
<th>en</th>
<th>ru</th>
</tr>
</thead>
<tbody>
<tr>
<td>continuative</td>
<td>a‘a</td>
<td>continue reading</td>
</tr>
<tr>
<td>resumptive</td>
<td>a~a‘a</td>
<td>resume reading</td>
</tr>
<tr>
<td>durative</td>
<td>aa</td>
<td>keep reading</td>
</tr>
<tr>
<td>iterative</td>
<td>e‘</td>
<td>read repeatedly</td>
</tr>
<tr>
<td>frequentative</td>
<td>pf e</td>
<td>read now and then chytyvat’</td>
</tr>
<tr>
<td>habitual</td>
<td>σ ∩ (e ∩ a)</td>
<td>used to read</td>
</tr>
<tr>
<td>dispositional</td>
<td>σ → (e → b)</td>
<td>will read</td>
</tr>
</tbody>
</table>
Table 12
The precise event type of English repetitive re- seems to be cause r~rr. This matches re-enter 'come in again', rebuild 'build up anew', regroup 'make a new group', repaint 'apply a new cover of paint', relive 'experience again'. and excludes resleep, rehelp, relose. The differences between some of the types are small, and looser types covering more than one mode of action on the list are common. For instance English read on actually covers both continuation and resumption, expressing a~a?~a. Russian inceptive za 'start' seems dedicated to nonprogressive events. A more specialised one is u 'from' for cognitive states: uznat' 'get to know'. Note that English must use get; start to know is funny. Minor modes like attenuative, absorptive, evolutive (Isachenko 1962, Forsyth 1970) involve nonaspectual implicatures of aspects or aspectual implicatures of non-aspects.

Many languages have derivational affixes which express or imply aspect distinctions. Derivational affixes can be classified as aspect operators by their input and output. Momentaneous or semelfactive suffixes produce closed event types out of open event types. Iterative (durative/continuative or repetitive/frequentative depending on input aspect type) affixes produce iterations of different types. Etymologically, iteration often comes from reduplication or some (other) pluralising device (affix, adverb or quantifier), or goes back to verbs expressing continuation or permanence (sit, remain, live, go on). Iteratives seem predominantly derivational. (Bybee 1994:161). Bybee et al. (1994:164,170) suggest that repetitive grams further develop into habituals and continuative ones into progressives. Iteration can turn a transitive verb into an intransitive one (a process accomplishment with an implicit noncount object, Bybee 1994:172).

Alternating compositions of these two inverse derivation types are common. Lat videre see ‘see’, visere pf see ‘go see’, visitare (pf see) ‘go see often, visit’, Finnish heilataa pf swing ‘swing once’, heilua swing ‘swing continuously’, heihahtella (pf swing) ‘swing intermittently, back and forth’. Affixing with bounding particles (intransitive prepositions and adverbs) is a productive way to produce changes (achievements and accomplishments) out of states and activities in many languages. Inceptive affixes can form initial or comparative changes out of states and accomplishments. Inception is often a specialisation of a more general perfective gram (Kühner 1898:156). Latin aere dry ‘be dry’, arescere (become dry) ‘dry’, exarescere become dry ‘dry out’.

Causative-reflexive-intransitive alternations produce aspect changes These are not pure aspect shifts in that the diathesis of the verb also changes. Examples: English hide(tr/refl/itr) translates into Finnish variously by pilottaa cause become hidden (put into hiding: accomplishment), piloutua refl cause become hidden (put oneself into hiding:accomplishment), piillá hidden (be hidden:state) or püleskellá (refl cause stay hidden)‘ (be in hiding: activity).

Aspect features
Aspect features are event types which cross-classify to generate a matrix or taxonomy to define other aspect types. This section singles out certain central aspect features definable in terms of the event calculus.
An event type is open (noncount) if it is closed under unions (i.e. \( e \subseteq e \)). An event type is closed (count) if its complement is open (i.e. if \( e \cap e = \emptyset \)). An event type \( e \) is complex (extended) if it contains at least two separated parts of the same type, else it is simple (atomic, simply connected). An event is an atom (in \( e \)) if it does not contain proper parts (in \( e \)). An event type \( e \) is atomic if every part of \( e \) includes an atom, and nonatomic if \( e \) has no atoms.\(^{23}\).

A state is, open, and simple. An activity is open and extended. An achievement is closed and simple. Simple events can be contracted to a point, complex events cannot.

The definition of extended in terms of subevents is really equivalent to saying an event takes time, or \( e \cap t \). This reflects the intuition that an extended event cannot be contracted to a point, because it has at least two separate parts.

Holisky (1981) suggests question tests for central aspect features: how long (open events), at which point (simple events), and how (impure events). This last test is based on the idea that how checks for subevents. It is not definitive, for why/how questions rather pair up with the explanation of universal and existential claims, respectively: why necessary/how possible. The how test correctly distinguishes impure sleep from pure be asleep (How did you sleep/were you asleep), but it misclassifies pure events how did you know/notice it, where how asks for antecedents, not subevents.

**Aspect operators**

There is a pervasive process-product ambiguity in aspect terminology: the same names are used of aspect operations and the resulting event types. In my parlance, aspects are primarily grammaticalised expressions or constructions which map event types to event types.

There is a small number of prime candidates for universal aspects: the grammaticised open-closed contrast imperfective and perfective in the first rank, followed by their more complex (and more concrete) antecedents progressive and perfect, with the leftover generic (dispositional and habitual) aspects following next. From there on, there is no sharp cutoff between major and minor aspects, but a grid of coarser and finer distinctions (McCoard 1978:9):

there’s a whole list of relatively concrete meanings which may be associated with perfective or imperfective forms: the perfective is said to indicate short duration, temporal limitation, punctuality, completion, inception, result […], while the imperfective indicates iteration, durativity, conation, nontermination, habituality, progressiveness, and the like. The trouble is that none of these conceptions - sometimes called Aktionsarten (German for ‘kinds of action’), especially if they involve lexical derivation - applies to more than a subset of cases. […] For instance, “indicating the end of a situation is at best only one of the possible meanings of a perfective form, certainly not its defining feature” (Comrie 1976:19).

Accordingly, a general definition of the main aspectual contrast is rather abstract:

perfectivity indicates the view of a situation as a single whole, without distinction of the various separate phases that make up that situation; while the imperfective pays essential attention to the internal structure of the situation. (ibid., p. 16)

My definitions of the major aspects are very similar to received wisdom.

**Perfective**

In topological terms, the perfective turns an event type into a (half)closed event type, one which contains one or both of its limits (Timberlake 1982:311).\(^{24}\) The definition specifies the outcome, but not the means. The rest of the calculus provides the means.

\[ \text{pf } b:e \]

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\(^{23}\)Nonatomicity, under the name of temporal ill-foundedness, replaces the subinterval property for states and activities in Cooper (1986:27).

\(^{24}\)Cf. Eberle and Kasper 1994:155: The PS presents the event it introduces as temporally closed; the Imp presents the state it introduces as temporally open. Langacker’s (1987:154) definitions of the terms process, perfective and imperfective is somewhat loose: ‘processes that involve a change through time will be called perfective, other processes will be called imperfective’. Otherwise, his conceptualisations are closely similar with mine.
To satisfy the definition, a perfective does not have to do anything to a closed event type (but it can); while it coerces an open event into a (half) closed one. Perfective is a count operator in the domain of events: it turns noncount events into count ones. This is reflected among other things in deverbal nouns. departure is a count noun.

Formally, perfective reflects the topological notion of boundary and the Boolean notion of complete join/meet. Given that closed events are filters and open events are ideals, the following Boolean duality holds:

\[ \neg \text{pf e} = \cup \text{pf e} \]

That is, the imperfective and the perfective have a common bound, approximated from above by the perfective and from below by the imperfective.

The definition of perfective as half closed or closed makes it a disjunctive event type. This is reflected in aspect literature as a schism between two definitions of perfective, based on limit or totality, respectively (Dahl 1981,1984). Both views are represented in Razmusen (1891:379, cf. Leinonen 1982:39):

The perfective verb, it seems to me, originally signals an action as reaching its goal (its boundary), and then in general an action seen as a whole (beginning, middle and end together).


perfectivity indicates the view of a situation as a single whole, without distinction of the various separate phases that make up that situation, while the imperfective pays essential attention to the internal structure of the situation.

The schism can be traced to the following sources. First, there is a genuine difference between closed (irresultative) and half-closed (resultative) event types. In lexical aspect languages closure is derived in diathesis from result complements, and produces half closed event types. Grammatical aspect is derived in phrase structure from open events using time adverbials, and produces closed event types. Second, in closed aspect languages perfective is marked, in open aspect languages it is imperfective. Slavicists, with a marked lexical perfective, stress telicity (half-closure). Westerners and orientalists with marked grammatical imperfectives stress totality (closure).

Combining the two views, the perfective prototype for an open event type a can thus be defined as ∃aa-a. The perfective thus denotes the smallest or the largest subevent of an open event type. This is the duality between some a and all a, the beginning of a and the completion of a.

The duality of perfective explains its ambiguity between closed and half-closed events, punctual and telic. It is another thing why language should group event types asymmetrically in just this way. This temporal asymmetry of the perfective in favor of inception over cessation might be called the perfective paradox: unless specifically marked, a perfective of an open event type denotes its beginning or its discontinuation, not just the end.

One simple observation is that an event is of the same type as its inception, while the event following its cessation is its opposite. By the time an event ends, it is all there, whereas at the time it begins, it is not yet in existence and may never become so. There are beginnings without ends, but there are no ends without beginnings (Galton 1984). This accords with the observation that there are many inceptive verbs but few egressive or desinitive ones (Johanson 1998), mostly suppletive: have/get/lose. The half-closed perfective ∃aa is resultative, the closed perfective ∃aa- is irresultative (it is a cycle which ends in the same state it begins with), while the outgoing change a- a is really the inception of the complement event type ∃a.

There is a topological construal of these intuitions. The half open event type ∃aa is the closure of a in the past order topology of a, or the event type <a of pasts of a, or in the relative topology defined by the event type <a, or all events ending in a. The half closure of a is the closure of a relative to a model of time where future is not actual.

For a closed event, if pf b is written out explicitly as ∃bb-b, the perfective does do something to a closed event: it turns it to a cycle of itself. For instance, die becomes die once. If the event type is unique in the way dying is, truth is preserved: one who dies dies once, and of course conversely. With noncounting event types b, iterated perfective pf* b actually becomes a series, i.e. open.

In general, does not seem right to presume that He fell yesterday means the same as He fell once yesterday. On the other hand again, He fell a moment ago and He fell once a moment ago seem pretty much the same, when the fit of the time and the event is tight enough. He fell sometime yesterday and
He fell just once sometime yesterday are again equivalent. An additional existential quantifier on reference time allows contracting the boundaries to points, and the focus is again on the event between them. In sum, the perfective of a closed event is equivalent to the simple aspect within a short enough reference time (where the event becomes unique).

Analogous observations apply to the perfective of open event type in a language that has a perfective. The interpretation of Portuguese chovou ‘it (has) rained (pf)’ that first comes to mind is it rained for a while (it started to rain, it rained, and it stopped raining). But it is not the only one (and possibly not even the commonest one). Chovou can also mean ‘it rained at (or for) a specific time t under discussion’ pf(rain\[^{\text{t}}\]), whether or not it went on raining afterwards. It does not always imply the rain stopped, only that something else in the context it was matched with did. If someone asks (as a geographical question, or as a tourist reminiscence) Chovou em Bergen no Inverno passado? ‘Did it rain in Bergen last winter?’ you can answer Si, chovou, without implying that the rain (has) stopped (it probably hasn’t, knowing Bergen), only that the time talked about is over. Similarly foi bonita? ‘Was she pretty?’ need not imply the prettiness ended, just that looking at her did.

English You were always my best friend or Portuguese Sempre quis saber ‘I always wanted to know’ do not imply that you aren’t my friend any longer or that I have stopped wanting to know. What a perfective aspect really says is that an event expressed with the verb is closed, but it does not say exactly what the event is that is closed. Cases where a verb is perfective and the verb event type isn’t closed are cases where there is some narrower event type expressed or implied which is closed, some further specification which makes an event type expressed in the sentence closed although the event type denoted by the verb alone isn’t. Scoping may be involved. Take for instance

Estivemos aqui bastante tempo, então? ‘We have been here long enough, haven’t we?’

Here, the conversants are still “here” so be here is not closed, nor even be here long enough. The paraphrase would be We have been here for t, and that is long enough, and the underlying be here for t is the closed event licensing Perfeito.

One interesting thing about these observations is that they indicate a perfective event is definite (contextually unique). Of course, this result holds relative to the aspect type it applies to. The uniqueness implication is defeated if the input aspect type is plural or definite, for ‘there is exactly one sequence of several events’ entails ‘there are several events’ and ‘there is exactly one of this’ says nothing more than ‘there is this’. A unique event is trivially perfective (Galton’s 1984:56 once-only events are such). I shall survey the different senses of a perfective in the section on the Portuguese Perfeito, and return to the question of the definiteness of the perfective in the section on definite tenses below.

The perfective adds (coerces or entails) a boundary to an event. It does not say what that boundary is, except that it belongs to the complement of the event bounded. If the event type is inherently closed, the boundary can be inferred from the event type. Else some other bounding event must be found to explain the perfective, which may in turn help determine just which event is being referred to. It can be an explicit bounding complement or modifier, or it may have to be inferred from context. Examples of this will come up in the sequel.

Perfective says nothing about how long the result state of an event continues after the event. Consider for instance Portuguese já comei ‘I already ate’, which is the normal translation for the English perfect I have (already) eaten. The result state of eating is that one is satiated, so representing eating as become satiated ¬ss, pf eat unpacks to (¬ss U ss U s¬s)s, ¬ss, (¬ss U ss U s¬s), which implies I ate some time ago, I haven’t eaten since, and I may or may not be hungry now.

Smith (1991:103,109) notes languages with a perfective differ in the treatment of simple states. Some languages (English, Russian) as a rule do not mark aspect on them, others (the Romance languages) do.55 This correlates with the type of aspect system. Russian, with unmarked derivational imperfective, does not. Romance languages, with marked grammatical perfective, do. English only marks progressive, which is ruled out for simple states.

Perfectives develop from perfects, semelfactive (momentaneous) affixes, result particles (prepositions and adverbs) and phasal verbs. Many if not all languages use result adverbs to close events, but they differ in the extent this is systematic (lexicalised or grammaticalised). English is half way there: use use up, write-write down etc. Russian forms perfectives with adverbial prefixes, momentaneous

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55Russian can mark aspect on some states: byt’, byvat’, pobyt’, pobyvat’, ‘be (unmarked, habitual, cycle, series) somewhere’ but need not, and usually does not (Rassudova 1967:116ff).
suffixes, and suppletion. Altaic languages exhibit constructions with converbs originally meaning 'give, put, send, reach, throw' (Johanson 1998).

**Imperfective**

The *imperfective* forms an open event out of an event. Quote: “The imperfective aspect expresses an action without indicating the two limits of the action, without all the elements constituting a totality, but with particular emphasis on its middle”. (Leinonen 1982:39 citing Sheljakin 1972).76

\[
ipf \ a \ e
\]

In Boolean terms, the imperfective takes an event to a Boolean algebra generated by it as the bottom element (plural) or top element (mass). Topologically, the imperfective produces interiors and neighborhoods. Two consequences: the imperfective denotes an open event type, and it *coerces* its input to an event type which is or includes an open event type. Imperfective is idempotent: \(\text{ipf}^+ \ e = \text{ipf} \ e\). Thus the imperfective does not have to do anything particular to open events (but it may do something, e.g. change scale), while it turns accomplishments into activities and coerces achievements into iterations. Thus the imperfective subsumes progressive and iteration. We might say that the imperfective is a *noncount* operator in the domain of events, subsuming progressive, as a *partitive* operator and iteration, as a *plural* operator.

I do not mention particular selection and construction operators out of the definition of the imperfective above, but rather define the aspect as a disambiguator, or output filter. The imperfective can also be defined constructively as an arbitrary composition of the iterative, progressive, and generic aspects, i.e. as the regular expression \((\text{id} \mid \text{prog} \mid \text{gen})^+\) of aspect operators. This obviously makes \(\text{ipf}\) idempotent.

A partial compositional definition of imperfective is \(\text{gen prog} \ e^+\), which covers as degenerate cases progressive, iterative, transient, and existential uses, by letting one or more of the operators \(\text{gen, prog}\) and \(e^+\) reduce to identity in turn. An unmarked imperfective in particular covers \(e\) itself.

Narrower definitions may be right for the imperfectives of given languages, depending on what other aspects the language has, i.e. whether imperfective is obligatory, optional or preferred to express progressivity, iterativity, habituality and so on.

Imperfective forms evolve from progressive periphrasis and iterative derivation (Bybee 1994:158-9). For instance, the Latin imperfect *ibam* ‘I was going’ shows the traces of an auxiliary *be* in the ending (a progressive), the Portuguese *Imperfeito* ends in *ia < ibam*, the Russian secondary imperfective is a frequentative stem. A progressive is generalised to an imperfective by extension to iterative and habitual contexts (Bybee et al. 1994:141).

Although iteration of an open event always produces an open event, resolution may change with iteration. Thus the imperfective of a state can give it a ‘habitual’ feel without necessarily implying that the state occurs intermittently (Johanson 1998:§4.2). Czech makes a distinction between *jsem ji míval/mil rád* ‘I used to like/liked her’, where the imperfective implies remoteness. In my terms, it expands the resolution of the events and thereby also makes the distance to the past longer. Compare English past habituials: *I used to smoke yesterday* sounds funny (Kucera 1981:184-185, Lindstedt 1985:127).

**Cross-linguistic combinatorics**

Cross-linguistic combinatorics of imperfective vs. perfective can be studied best in languages like Russian and Greek which run the whole gamut of imperfective vs. perfective stems (Forsyth 1970, Hedin 1998). Similarities and differences between Russian and Greek observed by Hedin can be traced to corresponding formal properties.

Telicity. The perfective formula \(\neg e^+e\) divides up into two types of perfective, a half closed telic type, denoting changes, and a closed atelic type, denoting cycles. Russian *napisal pis'mo* ‘wrote up (pf) a letter’ is an example of the former type. Russian *pochital pis'mo* ‘read the letter a little/for a while’ is of the latter type. Modern Greek *e grapse ena gramma* ‘wrote a letter’ is vague between the two, it can denote a change or a cycle.

Negation. The denial of *any* occurrence of an event type *at all* is an open aspect type and the strong denial (contrary or pointwise complement) of one. A closed denial of a closed aspect type denies the

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76 The arrow here should have a serif in the beginning. It indicates that \(\text{ipf}\) is a mapping from any aspect type to open aspect type. The same goes for other definitions of the form \(\text{operator: aspect type} \rightarrow \text{aspect type}\).
assertion but leaves the presupposition in place. The presupposition is that an *occasion* for the event type is present, the assertion denied is that the event reaches closure then. Though the assertion fails, the implication of a definite occasion remains, and thus the event type of the denial remains a closed one. This works for Russian *Passagir ne zagovarival/zagovoril* 'the passenger would not start talking/did not start talking (ipf)' vs. ¬(*speak.speak*) as well as Greek *den miluse/milise* 'He did not talk/say anything (pf/ipf) ~*speak* vs. ¬(*speak.speak.*speak*).

Implicative. The implicatures of an imperfective imperative are strikingly similar in Russian and Greek. If imperfective denotes *Ving*, the process, not the accomplishment, an imperfective imperative should mean *get/go on Ving*, and that is what it means. Common English turns of phrase here are *go ahead, get on with it*.

gr Na su *kenoso* to ghala su? - *Kenone!* Shall I pour (pf) you your milk? - Go ahead, pour away! (ipf).

Markedness. The key observation here is that the formula *ipf e* does not entail *e* while perfective *pf e* does. But imperfective does not entail ¬*e* either, but at best implicates it. Even an equipollent marked contrast, defined as *ipf e *pfe, does not entail ¬*e*, though it of course does entail ¬*pf e*. The difference *ipf e *pfe of imperfective and an unmarked perfective does entail ¬*e*. Russian imperfective is (mostly) the unmarked member of a privative opposition. The modern Greek opposition is equipollent (Hedin 1998). In either case, *ipf e* is compatible with *e simpliciter*, or 'the bare fact' or 'simple denotation' of *e*.

The overall thrust of Hedin (1998) is that (unmarked) imperfective is used to denote event type as contrasted to event token: "the situations are considered in a static, non-temporal perspective, as types". Examples. gr *Pjos to eleje* (ipf) 'Whose words were those?', ru *My zavtrakali* (ipf) *v vosem chasov* 'Breakfast was at eight'. Compare also ru *pisl* (ipf) *karandashom* 'he did the writing by pencil', fr *L'année derniere je deménageais* (ipf) 'what I did last year was move house'. The paraphrase in each case is a support verb of an open event type. It seems right to say that imperfective boils down to simple (i.e. no) aspect here.

**Progressive**

Poutsma (1921) distinguishes three senses for progressive, exemplified by

In this picture, the train is arriving at the station.

One is a straightforward *interior* progressive (Poutsma 1921:§29) *Arrive*, said of a train, is an event type which is vague between achievement and accomplishment. The event type looks pointlike from far off but is extended from close by; pointlike if one times arrival by one end of the train and extended if by both ends. The slow arrival of a long train to the station is an event that takes appreciable time from first entry to full stop.

The reason the process can appear external to the achievement is that it is detachable (Smith 1991), i.e. the change can be contracted to a point. Although the train keeps arriving for minutes, the exact moment of arrival can be pinpointed as the moment it enters the station (starts arriving), or alternatively, the moment it comes to a stop (has arrived).

This second sense of the progressive is the *neighborhood progressive* of an achievement like the train is arriving "implies only the approach to the transition" (Quirk et al. §3.41, Kucera 1983:179).

The next train is arriving in ten minutes now.

This is a future (futurate) progressive (Poutsma 1921:§32). A future progressive denotes a temporary plan (Allen1966:215, Johnson 1981:156, Lewis 1986, Declerck 1994:97). It is odd for unalterable future *The sun is rising at five tomorrow* (Gabbay and Moravcsik 1980:73.Cf. Dowty 1979:154ff, Huddleston 1967:786). Leech (1987:23 ) (Vlach 1993:242) points out that the future progressive is a near future. This is not a metric entailment, but a topological one: some preparatory process leading up to the future event is already in progress. This process need not be specific to the future event; only as things are proceeding now, the future event will materialise.

As Mittwoch notes, *John was working for 2 hours* can be a future progressive of form *prog <work for 2h* 'John was temporarily scheduled to work for 2 hours in the future', perhaps even *(prog <work) for 2h,* 'for 2 hours there was a plan that John should work in the future'.

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77Santos 1966:183 claims there is no future progressive in Portuguese, although the simple present can be future.
The third sense of progressive is a *boundary progressive* of imminence future, paraphrased by *about to*, *at the point of*, *on the verge of*, *almost*, *nearly* (Poutsma 1921:§30):

You are making a mistake if you hire him.
I was throwing it away when he told it was valuable.

Here, no protracted process is implied, but rather, an initial state next to a transition. *Be* cannot be replaced by *keep* here. Time adverbials for *a while*, *quickly*, *soon* are infelicitous. I call this type a *boundary or point* progressive (Johanson 1998:§10.2.1.3-5).

Depending on event type, the progressive thus denotes being in a temporary state, process, or left neighborhood of an event type. Topologically, it denotes an event in the *interior* of an extended event (*in*) or in a left neighborhood or at the boundary of an atomic one (*at*). The progressive is thus inherently a compositional aspect (Cohen 1989:104):

| prog | in p | of | e:e |

A common type of progressive can be read off directly from the above formula. Bybee et al. (1994) propose that the core meaning of the progressive construction is ‘the subject is located in the midst of doing something’.

As defined so far, progressive is idempotent: prog prog p = prog p. This may help explain why iterated progressives are rare. English progressive in particular allows a stronger explanation: it produces a state out of a non-state, so it does not satisfy its own input conditions (Dowty 1986:44)


Progressives, like states, provide background for perspectival aspect: Max was here/running when I arrived. Dowty (1986:44ff) proves that the *in p* clause of the progressive entails the subinterval property of states.

Many progressives are space-time metaphors of location (Jespersen 1949:§12, Anderson 1973, Comrie 1976:98-103, Bybee 1994:129-133, Johanson 1998:$7.6$). Examples of locative periphrases for the progressive *pt está a trabalhar* , *is at work* fr *Il est en train de travailler*, *is in progress of work* sv *Han håller på att arbeta* ‘holds on to work’. Han är i färd med att arbeta ‘is on the way with work’, fi *Hän on työssä* ‘is in work’, de *Er ist dabei, zu arbeiten* ‘is at work’.

Progressives are formed from nonpast participles, gerunds, infinitives and nominalisations combined with locative or partitive prepositions and auxiliary verbs (Blansitt 1975, Johanson 1998, Bertinetto/Ebert/deGroot 1998). The development path proceeds from a locative construction through interior progressive toward a general imperfective covering iterative and generic uses (Bybee 1994). Motion verbs tend to replace progressive with an event noun paraphrase *flying-in flight, moving-in motion* (Smith 1991). This can be related to the fact that motion (kinetics) does not entail causation (dynamics). I return to this in the chapter on diathesis.

**Imperfective paradox**

A traditional puzzle for the progressive is the imperfective paradox, i.e. that *be building a house* does not imply *build a house* (Bennett 1974:66, Dowty 1977, Nute 1979,1989:528, Galton 1984, ter Meulen 1985, Dik 1989:94, Smith 1991:98-100, Johanson 1998:$10.2.1.3$). A paradox arises only if the progressive is supposed to be an extensional operator in linear time. It can be avoided by allowing either possible worlds or intensions (event types) The gist is that progressive affords a partial view on an event, the simple aspect denotes it in its entirety. What is only partially shown may change, while what is entirely in view is fixed.

Goldsmith and Woisetschlaeger (1976,1982) argue against treatments which try to make the simple/progressive distinction in terms of the time line, on the grounds that the real line is too poor for it. They construe the English simple/progressive aspect distinction as a fundamentally modal distinction between what they call *structural* and *phenomenal* properties. Structural properties of an object are those whose going or coming mark a change in the the object, while phenomenal properties may come and go without changing the object. In *This law/bill raises/is raising the price of oil by 10 cents a gallon* the simple aspect explains the essence of the law or bill, the progressive its accidental consequences.
In my view both schools are right, and the extensional time line view and the intensional property view are dual. In the former, the modal content comes in through branching time, in the latter, from the finer grain of intensional objects.

Intensionally, the imperfective paradox can be accounted for by allowing the subevent relation of in the definition of the progressive to relate event types, not event tokens. That is, one can be building a house without actually building a house if one is in a process of the type involved in building a house. By the type-token duality, the direction of entailment is reversed. For instance, one is building a house while one builds the foundation of one. Event type build a house would entail event type build a foundation, that is, every build a house token includes a build a foundation token. Build a house entails build a foundation, not vice versa. In a rather weak sense, then, one who builds a foundation is thereby building a house. It is weak if it licenses saying that one is building a house when one is really only aiming for a foundation.

Usually, we seem to imply something both stronger and weaker with the progressive. A standard example here is Partee’s Mary was making John a millionaire (Link 1998:255). The progressive seems to imply no particular event, but a presumed causal connection: whatever Mary was doing was causally related, i.e. contextually (counterfactually) equivalent against some set of background assumptions, to John becoming a millionaire, i.e. there is a counterfactual theory (situational constraint) \( \sigma \) available which entails the \( \sigma \subseteq \text{Mary p} \rightarrow <\text{John rich}. \) For another example, the event type of stepping off the pavement is typically, ceteris paribus, or at least hopefully, equivalent to the event type of crossing the street, although not all actual starts are included in actual crossings the street.


One who builds a foundation is possibly building a house (an entailment is consistent with its premise), which is basically what the possible worlds account says: prog (p cause become q) is true iff p is true and q is possible (Dowty 1979:136ff), intended or expected (Dowty 1979:149); in general, entailed by p in some contextually given theory (Galton 1984:127) or channel c (Barwise and Seligman 1994). 78 Asymmetry of time is crucially involved in the imperfective paradox, for entailments are asymmetric: from be building a house one can infer begin building a house but not finish building a house. (This asymmetry is pointed out but left unaccounted for in Smith 1991:99).

The key examples in Goldsmith and Woisetschläger also conform to both views:

Help! Police! The statue of Tom Paine stands/is standing at the corner of Kirkland and College streets! (Gleitman)

Is standing is much preferred if the statue is not in its rightful place, i.e. it is at a temporary location.

A difference between announcement/prediction and observation/eyewitness report is clear in the following example. The announcement format has a comical effect for unintended interruptions.

And now I take the flask of sodium nitrate and pour the contents into this beaker; now I light the bunsen burner and heat it to a boil ... And now I --- whoops --- sneeze; and now I reach into my pocket and take out my handkerchief...

Now he is picking up a glass flask, and pouring its contents into a beaker. Now he’s lighting the bunsen burner and --- wait! He’s reaching into his pocket for what seems to be his handkerchief!

The explanation: the progressive is timed by observation events, events in the simple aspect time themselves.

Thomason/Stalnaker (1973) study inference patterns for adverbs like partly, halfway. They note that unlike usual restrictive adverbs, they don't entail the head, but if anything vice versa, rather like weak modals:

He climbed partly/halfway/almost/possibly to the top.

78 The quantification there exists a channel imports a modal element here. The existence of a theory does not entail that it is true nor is entailed by its being false or consistent.
This is another instance of the asymmetry of time in a branching future model. A halfway event entails the start but does not entail the end. A contrary change lets the inference to go through:

He opened the door halfway.

This does entail he opened the door (it was no longer closed, if not fully open either.) Nearly/almost differ from halfway in that they entail that the event denoted was a near miss. He almost opened the door can mean he never started or that he did not quite finish. These words therefore serve to tell apart achievements and accomplishments.

**Interior progressive**

The interior progressive of an extended event type is analogous to a mass term formed out of a count noun (e.g. a text/text) in that it goes from an individual to its divisible internal parts. In other forms, it is a partitive or inclusion operator (Mittwoch 1988, Löhner 1988:181, Herweg 1991). In fact, it is expressed by the partitive case in Finnish.

Taylor (1977) and Dowty (1979) in fact argued that progressives can only be formed out of interval predicates, in my terms, extended event types (event types which have temporal parts, and thus cannot be contracted to a point). This is not the whole story, however, as Zucchi (1998) points out, given the difference between John/the motor was being noisy.

There are two dimensions the partitive operation can operate on, the time dimension and the subevent dimension (Gabbay and Moravcsik 1980:74). Thus English progressive requires that \( p \) is a process (Timberlake 1982:311, Chung/Timberlake 1985). Vlach (1981a:291) specifically argues that ‘topologically specified’ (purely temporal) truth conditions for the English progressive must fail, and that any correct account must make central use of the notion of a process. Zucchi (1998) distinguishes different varieties of the English progressive of states depending on the type of process involved. The copular variety is being A is agentive (entails do), is lying is a dynamic or temporary state and is resembling more and more a comparative change (Zucchi 1998:359).


In the degenerate case, \( p \) can be any open event type, in which case interior progressive reduces to a temporal part operator.

Interior progressive is open. It is extended to the extent that it entails a process. As a special case of the imperfective aspect, progressive implicates incompleteness (Jespersen 1949, Palmer 1987:§4.1.2). I do not require the progressive to pick out a proper part of an event. Most, and the prototypical, parts are proper anyway. More to the point, the absence of entailment to completion characteristic of the progressive is guaranteed already by allowing the parts to be proper. By markedness, a marked progressive implicates the narrower meaning.\(^79\)

Leech (1971) even claims the progressive conversely entails the negation of the perfective, e.g. that Who has been eating my porridge? should entail that some porridge is left. This much cannot be entailed: given that perfective entails the progressive, a contradiction would ensue. Mittwoch (1988) rightly points out that She has been eating your porridge, it is all gone is consistent. The converse inference is a typical conversational implicature (like some entailing not all). Compare Hatcher’s (1951) I have been writing a difficult letter; thank goodness it is finished.

Mittwoch (1988:224ff, following Bennett/Partee 1972, Cresswell 1977:13, Dowty 1979, Richards 1984, Heny 1984) requires that the progressive denotes proper subintervals. Bennett/Partee (1972) restrict evaluation of the progressive to points. Since the progressive is a state, the distinction does not amount to much of a difference: if there is a subinterval there is a proper subinterval and vice versa. However, some of Mittwoch’s own observations can be used to support the weaker position taken here. The simple tense and the progressive seem simply equivalent in

The exact time John was wearing/wore sunglasses was when I had lunch with him

If wore had to properly include lunchtime in order for was wearing to match it exactly, the two forms could have different truth values. I don’t think they do.

In English, marked progressive contrasts with unmarked simple form here. When imperfective is the unmarked form (as in Russian), the entire event is included in the denotation, and no certain entailments about completion can be drawn.
A similar question is whether a progressive always denotes a nonfinal part of an event. Dowty (1979) makes progressive quantify over nonfinal proper subintervals. Langacker (1982:281) says the progressive focuses attention on a single, arbitrarily selected internal point of a process. An often quoted apparent counterexample to these claims (Vlach 1981) is the imperfective paradox: in He was telling me something when he was interrupted, the point of interruption is the last point of actual telling. This is not very convincing: counterfactually, the story went on. Hamann (1989:79) cites as evidence sentences like Before I was working, I was unhappy and After the horses were running, he tried to place a bet. I do not think these sentences show anything about the boundaries of the progressive.

Smith (1991:119), looking for differences between progressive aspect and stative event type, argues progressive must be medial because it does not support an inceptive reading (narrative progression), while states can:

When he became manager, everyone was unhappy.
When he became manager, everyone was (soon) working overtime.

Jameson switched off the light. It was pitch dark around him. (Cooper 1986)
John entered the kitchen. (In the next moment,) Mary was pushing him out again.

While a state in simple aspect is vague between simultaneous and sequential readings; the progressive seems to require soon or in the next moment to get a sequential reading. Vlach (1993:243) too observes that progressives group with locative statives like at work or away against nonlocative statives like alone or free in that they do not support narrative progression.80

When Allen left, Betsy cried/was alone.
When Allen left, Betsy was crying/away.

This property of the progressive is exploited in the so called interpretative use (König/Lutzeier 1973, König 1995, Bertinetto/Ebert/deGroot 1998), where the progressive helps fold two events into one:

If we selected the best described languages, we would also be selecting the languages with the largest number of speakers.

This confirms Dowty's (1986:55) point that progressive need not denote a proper interior subevent to produce Smith's observation. A sufficient condition is that a progressive is not closed, i.e. it does not have to include the boundary. The interior cannot be reached without first reaching the boundary. Narrative progression matches a locative or progressive state with the final state of the preceding event, which places the boundary of the state somewhere earlier. This does not prevent progressive from denoting any part of an open event, including an open prefix. Markedness makes a difference, however: French imparfait differs from English progressive here (Molendijk 1994). More on this topic in the section on narrative progression.

A suggestion of the progressive is that it has duration, it goes on for some time (it is a ‘continuous tense’; Sweet 1900, Palmer 1987:§3.1.3, §4). This is implied by the Montague-Scott definition (Scott 1970) of the progressive as true of the interior of an event (an open, hence extended region). Processes are extended, so if there is one point within a process there are others next to it. This does not mean that the progressive should not be a state (true pointwise), it only implies that it is not true of isolated points (is not closed).

A complementary suggestion, felt in dynamic states like live or lie is that a progressive only holds for a limited time (has a ‘temporary aspect’ or at least subject to change). By denoting parts of some more encompassing event, the progressive implicates that the reference time is bounded by the latter. The progressive of a dynamic state I am living here instead of I live here thus disambiguates for temporary against permanent state (it is susceptible to change, Palmer 1987:§4.6.1).81

80 Compare euphemisms to avoid the event of death: has died-is dead-is away are preferred to simple He died.
81 Jespersen (1949:§12.7.3): “What do you do for a living? I write novels” refers to the whole of the man’s life, while “What are you doing for a living? I am writing novels” refers to the present time, including the immediate past and (presumably) some part of the future: I began writing novels some time ago, and have not yet given it up. Löbner (1988) actually proposes the progressive always coerces its argument to a closed event (cf. closed progressive of Galton 1984). This is not necessary: I am living here now as I always was and always will is consistent. Nor is the simple form specifically restricted to lifetime tasks, it simply has no particular suggestion as to duration.
A related consideration is that I am living here has finer resolution than I live here. The suggestion of short time, due to the contracted time scale, translates into implications of recency I have been living here and immediacy I will be living here in the past and future tenses. The fact that I must be going home feels more immediate than I must go home (Jespersen 1949:§13.4.6) can also be related to the fact that being going home is true at any time from the time of departure while go home denotes the whole trip (cf. I must be on my way).

Sweet (1900) and Poutsma (1921) are hard put to find a difference in meaning between I coughed/was coughing all night long. Sweet says the progressive emphasizes duration, Poutsma says it is more vivid. I venture to suggest that both impressions are due to a finer scale of observation times being implied by the progressive.

Leech (1969) concludes that the progressive has two apparently contradictory meanings, limited time extension and continuous. Examples of the two are The engine works/is working perfectly and The earth turns/is turning on its axis. There is no contradiction in the progressive simultaneously suggesting continuation (long duration) and temporariness (short duration), for there is a two-way comparison here: the event the progressive denotes is short but open, the event it entails around it is longer and possibly closed. It all depends what is compared to what. Besides, there is iterative shift: He has been leaning on the door may feel longer or shorter than He has leaned on the door depending on whether the progressive is iterated (making be leaning mean keep leaning).

Formally, the progressive does entail both boundedness and openness (these are both properties of in). These implications are not contradictory, it is consistent to have an open but bounded event type. As suggested above, Leech’s (1969) different feelings about is working and is turning reflect different analyses prog pf work and (prog turn)* respectively, selected on the basis of factual knowledge of the world.

There are obvious connections between type of progressive and diathesis. Interior progressive is the inverse operator of process accomplishment: be eating up prog pf eat equals eat. The progressive of a result causative which specifies the effect but not the cause is future. This can be expected, since there is no preparatory process for the progressive to pick out here:

The missile is hitting the target in twenty seconds.

In a typical process causative where the entire process is included in the specified time frame:

John is putting up the tent in one minute flat.

Motion verbs tend to have suppletive progressives cross-linguistically. In English, there is a choice between He is coming-going home and He is on his/the way home. The former can just confirm a plan, the second reports a position on the trajectory. Neither entails ongoing motion: one can make a stop while one is on one’s way. Finnish uses a separate set of locative paraphrases with motion verbs. E.g. English He is going is best translated with a derived nominal Hän on menossa ‘He is in going’, while Hän on matkalla literally corresponds to He is on his way. The regular interior progressive Hän on menemässä pois ‘He is in the process of going away’ is marginal, the point progressive Hän on menemäissällä pois awkward.

The rationale for this typological phenomenon is that motion is a simple process composed of changes of position: there is no other process causing motion for progressive to dig out. Simple (noncausative) intransitive processes in general tend to avoid progressive or have suppletive forms: sleep - be sleeping - be asleep, live - be living - be alive, drift - be drifting - be adrift, move - be moving - be in motion.

An objection against the Bennet –Partee analysis of the progressive is that it does not allow gappy processes (Kuhn 1989:529). This refers to the possibility of I sit here not entailing I am sitting here, me pointing at my seat taken by someone else. This is a resolution ambiguity Though simple aspect is more likely to be habitual than the progressive, with a dynamic event type both can be either. When the resolution is the same, the inference follows: I am sitting here this season is entailed by I sit here this season.

82 Jespersen (1949:§12.5.2): [in he is hunting] “the hunting is felt to be a kind of frame round something else; it is represented as lasting some time before and possibly (or probably) also some time after something else, which may or may not be expressly indicated, but which is always in the mind of the speaker. In this way the hunting is thought of as being of relatively longer duration in comparison with some other fact (some happening or state, or simply some period of time).”
Future progressive

Future or prospective progressive can be analysed as the interior progressive of a future simple tense \textit{prog fut e} (Poutsma 1921:§33), that is,

\begin{itemize}
\item in p of <e:e
\end{itemize}

According to the time table, a train \textit{arrives} every ten minutes, and in fact, one \textit{is arriving} in ten minutes. The progressive tells that events are actually proceeding toward, or drawing near completion in accordance with the generic prediction (a provisional observation, not the rule). Palmer (1987:§4.4.1) contrasts \textit{I start/am starting work tomorrow}. The simple present reports my schedule, the progressive my plan. The university announces a performative \textit{Examinations start tomorrow}, the papers may report \textit{Examinations are starting tomorrow}. Either she \textit{leaves} or I \textit{leave} is a threat, Either she \textit{is leaving} or I \textit{am leaving} a guess.

The existence of progressive future \textit{I am leaving today}, in the absence of a progressive perfect \textit{prog perf e I am having left today}, is an instance of the asymmetry of time: the past is necessary while the future is contingent. The event type \textit{p} in the interior progressive is by definition a process or a temporary state. The state of going to leave is open to opposite contingencies: my plan could change at any minute. Holding to a plan in the face of future contingencies is a dynamic state. The state of having left is not temporary - it never ends. The past needs no attention, it will keep.

Future progressive, unlike scheduled simple future, manages to make a future reference without a future time adverb.

\begin{quote}
We are having a picnic. Care to come?
\end{quote}

No surprise, since progressive denotes future on its own, as projects the end of the event to the future.

Point progressive

Point or boundary progressive \textit{be about to V, be on the verge of Ving} is the case where the variable \textit{p} of the progressive formula \textit{in p of e} denotes an atomic event in the immediate left neighborhood of an event \textit{e}, i.e. the boundary or \textit{verge} of \textit{e}. There are two major differences to the interior progressive. First, interior progressive supports inference from \textit{is Ving} to \textit{has been/begun Ving}, while the point progressive has the opposite entailment \textit{has not been/begun Ving}. Second, the interior progressive allows \textit{keep Ving}, the point progressive does not. The interior progressive is open, the neighborhood progressive is closed. \textit{He is going on} describes an uninterrupted process, the point progressive \textit{he is about to go on} denotes a pause which is about to end.

Consider \textit{reach} (attain). \textit{Reach} is a momentaneous transition which must be short-lived. It appears that its progressive \textit{be reaching} imposes a granularity where the final approach is a simple step, an atomic event, not a process. \textit{Is reaching equals is about to reach, is on the point/verge of reaching, not keep reaching}. It denotes a point where contact is imminent, not a process left to run through.

Though both \textit{approach} and \textit{reach} have progressive forms, they do not mean the same. There is a difference between \textit{The curve keeps approaching the line} and \textit{The curve keeps reaching the line}. The former can describe an asymptote, the latter can only describe a curve intercepting a line many times.

The difference between interior (process) and boundary (point) progressive is made explicitly in Finnish using internal vs. external locative cases \textit{olla Vmassa/Vmaisillaan}.

The boundary progressive is awkward with open event types which do not have boundaries to be at. Finnish

\begin{quote}
Olin syömäisilläni / istumaisillani pöydässä kun soitit. 'I was about to eat / sit at the table when you called.'
\end{quote}

is quite odd and gets better with

\begin{quote}
Olin rupeamaisillani syömään / istumaisillani pöytään kun soitit. 'I was about to start eating / sit down to the table when you called.'
\end{quote}

Portuguese too makes a difference between \textit{ir correr} and \textit{ir a correr} (Hundertmark 1982:§8.251-253). The first one is a near future ‘be going to run’, the second one a point progressive ‘be about to run’ with an implicature of interruption: ‘I was about to run when something happened (to stop it)’.

Formally, the point progressive and future progressive come to the same \textit{prog <e} or \textit{in p of <e}. The difference is whether \textit{p} is atomary (a point) or a temporary state.
Kuhn (1989:529) points out that a simplistic interior progressive analysis won’t work for a simplistic analysis of achievements such as *Baltimore wins* or *Mary starts to sweat*. If these events are true at a point only, how can another event happen in its interior? This objection can be met as follows. For one thing an achievement true at points need not be true only at points. Though the exact point of winning may exist, there may be an associated process as well. For another thing interior progressive is not the only progressive on the market. *Baltimore is winning* can also mean *Baltimore is about to win*. Both readings seem available for this example.

### Durative progressives

Further variants of progressive are obtained by combining it with aspectual verbs. French and Portuguese use *go* to describe comparative change progressive (*prog p*) - *aller (en)+-ant* in French, *ir+-ndo* in Portuguese, and *gå og V* in Norwegian. They can often be translated by *keep Ving* or *V little by little* (the latter is better for a closed reading):

- **fr** La vallée allait (en) s’élargissant ‘the valley kept getting wider’
- **no** Det er nettopp det jeg går og studerer på. ‘That’s just what I go and ask myself.’
- **pt** Ela foi ganhando terreno, ja não era a costureira, era a dama da companhia... ‘She had been gaining ground, she was no longer the seamstress, she was a lady in waiting’.

Note the Perfeito *foi* of *Ir* ‘go’ in the Portuguese example which makes the progress a bounded one (a short bit of comparative change). Not surprisingly, many languages express the iteration through reduplication:

- **fi** Laakso laajeni ja laajeni. ‘The valley widened and widened.’
- **jp** gohan o tabe tabe ‘eat rice repeatedly’

The combination *andar a+inf* ‘go on Ving’ in Portuguese expresses habitual iteration of the progressive (*prog e*). Predictably this shade can in some cases be brought out in English with *keep* or a habitual adverbial *these days*:

> Ele anda a aprender português. ‘She is learning Portuguese these days.’

> Todos andamos a fingir qualquer coisa. ‘We all keep feigning things’.

Tønne (2001) shows that Norwegian *gå og* pseudocoordination progressive selects open event types. It will be shown in the diathesis chapter that *go* denotes a comparative change. It follows that a pseudocoordination progressive of the type *go* will be denote a comparative change as well.

Progressives formed with dynamic permanences like *sit or lie* will similarly share aspectual properties with them.

### Absentive

Bertinetto/Ebert/deGroot (1998) distinguish between focalised, durative, and *absentive* progressives. The first class maps on my interior progressive, durative is this one. Absentive is a fresh locative progressive meaning *be somewhere Ving*, for instance Finnish *olla Vmassa*.

### Progressive combinators

This section surveys the combinators of the progressive with other TMAD devices. Compare the section on the English progressive below.

The progressive of *abstract accomplishments* like *John is running a mile in three minutes* prog (*run (mile in 3min)*) feels odd in the same way as Cresswell’s (1979) abstract accomplishment *He was polishing all the boots* or Johnson’s (1998) *They were playing chess for an hour*. Hirtle (1975:§354) notes that the English simple/perfect progressive can distinguish between absolute and relative quantity or frequency (just as perfective/imperfective aspect does in Portuguese, vide infra).

> It has snowed/been snowing a lot (much/often).

> My car has cost/been costing me $250 (a month) in repairs this year.

It *is snowing a lot now* or *I have been smoking two cigarettes* sound odd or incomplete (*per day?*), unless they entail it is snowing hard or often or that I have lit two cigarettes at once. This feature can be attributed to the absence of associated process in abstract accomplishments.

Vlach (1981b:75) finds progressive progressively less natural with more abstract adverbs of frequency: *be shaving every day / regularly / once a week / usually / never*, as it becomes harder to identify the associated process.
Mittwoch (1988:224) makes similar observations about *It was raining for 2 hours*. This too is because (and in so far as) there is no process associated with an abstract accomplishment. Such an accomplishment is more like a closed simple state. The progressive has a future feel to it, because there must be a plan involved, in absence of other dedicated process. With the scoping

\[ \text{John was working for 2 hours } \text{prog (work for 2h)} \]

thus means his shift was 2 hours long. Mittwoch’s other examples support this. *The level of the lake was rising 10 feet when we arrived* is odd, for how could one tell? *John was drinking three cups of tea when I arrived* may be funny, but gets better with *John was drinking his usual three cups of tea when I arrived.*

Mittwoch (1988) feels very strongly that progressives should not accept duration adverbials, i.e. that the scoping (\text{prog work}) for 2h is out for the above example. Similar opinions are voiced by Rohrer (1981) who stars *John was leaving for an hour*, Hatav (1989), and Bertinetto/Delfitto (1998), who question mark *Mary was dancing for two hours/until midnight*. Compare

\[
\begin{align*}
\text{It is raining for 2 hours.} \\
\text{It was raining for 2 hours.} \\
\text{It has been raining for 2 hours.} \\
\text{It will be raining for 2 hours.}
\end{align*}
\]

The present tense variant is the odd one out. The perfect and the future are fine. The simple past is bad if we add *when I arrived* but better with *steadily*. Or try replacing *be* with *keep*. The present tense is again odd: *It keeps raining for 2 hours* is a generic sentence, for *keeps* is an extended event type in simple aspect.

Note that (\text{prog rain}) for 2h denotes at least two hours of rain, while \text{prog (rain for 2h)} denotes an abstract state of being inside a rainy two hours. The present tense sentence can only match the point of speaking under the latter scoping. We saw that this scoping with an abstract accomplishment entails a plan; the problem is that rain is normally not a scheduled event.

In contrast, the past tense under the opposite scoping (\text{prog rain}) for 2h, disambiguated for by *steadily* or *keep*, is good. But this scoping makes the present tense sentence detached from the point of speaking, for two hours cannot fit in the point of speaking. The opposite scoping makes better sense as a series *It is raining for two hours daily.* \text{prog (rain for 2h)}

All this works as predicted. No rule is needed to limit the relative scopes of durative adverbials and the progressive. Commutativity with durative adverbials could be one index of grammaticalisation of the progressive.

Some examples Mittwoch rules out as ungrammatical seem quite natural. She admits that many native speakers allow such sentences, including e.g. Leech (1969:150), Palmer (1974:55), Bennett (1975:103), Dowty (1979:157), Bennett (1981) and Vlach (1981). The King James bible has them (Mittwoch 1988:248):

\[
\begin{align*}
\text{He was working all morning.} \\
\text{He is always losing things.} \\
\text{You were talking on the phone for hours.} \\
\text{They were working on that project for ages.} \\
\text{They were playing chess every evening for three years. (Johanson 1998)} \\
\text{He was coughing for half an hour.} \\
\text{Last year we were wearing winter coats till May.} \\
\text{Last year when I was in Boston I was living in Mary’s house for three months.} \\
\text{I was playing piano from ten to eleven o’clock (Leech 1969).} \\
\text{John was wearing sunglasses when I had lunch with him (Dowty 1979).} \\
\text{And Solomon was building his own house thirteen years and he finished all his house.} \\
\text{(1.Kings 7.1).} \\
\text{Lee was going to Radcliffe until she was accepted by Parsons.} \\
\text{Rob was working on the research project until he got the job at the U of M.} \\
\end{align*}
\]

One advantage of allowing this lot is that the compound tenses of the progressive can come out compositionally. The complex syncategorematic rules of Mittwoch (1988) are unnecessary.

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\[83\text{It has been raining for two hours every two hours} \text{ is a convoluted way of saying} \text{It has been raining all the time.}\]
Contrary intuitions may reflect constraints operative in other languages. French closed event types seem to exclude imperfect: Rohrer (1981) stars Jean traversait l’Atlantique pendant deux jours ‘John was traversing the Atlantic for two days’, and Vet Jeanne copiait la lettre pendant des heures ‘Jeanne was copying the letter for hours’. Mittwoch (1988:249) also claims that the Spanish progressive and the French imperfect do not accept duration or frequency adverbials. As Bertinetto/Delfitto (1998) point out, languages like Spanish or Portuguese allow a perfective progressive here. Note the English translation kept, which is a continuation causative.

es María estuvo pintando la pared hasta la media noche/durante dos horas. ‘Maria kept painting the wall until midnight/for two hours.’

In Italian, progressive is passable when there is a reason for it, e.g. when it matches the event to another:

it Maria stava giocando a tennis dalle 2 alle 3 quando tu credevi che stesse studiando. ‘Mary was playing tennis from 2 to 3 when you thought she was studying.’

In English too, one only uses progressive with tight adverbials of time for a reason. In general, iterative progressives make better sense than interior ones. I was using product X until I discovered product Y sounds perhaps even better than used or kept using because it suggests habitual behavior instead of a considered plan.

In general, a closed cycle of a progressive pf prog e, denoting an irresultative past temporary state or (Galton’s ‘perfective’) is an identifiable event type cross-linguistically (Declerck 1997:194).

I’ve been thinking. (I may have an idea.)
You’ve been working too hard. (You need a rest.)
You’ve been drinking. (I can smell it.)
He’s been talking about you. (I know something now.)
Someone’s been tampering with my books. (They are upside down.)
Who’s been eating my porridge? (There are traces in it.)

Portuguese uses perfeito progressivo here:

pt Estives a falar com ele. ‘You have been (pf) talking (prog) to him (You have done some talking to him).’

The progressive removes result and the perfeito adds closure: something has happened which has not run to completion or has been undone, but has left a trace. This is a prototype existential perfect.

Bertinetto/Delfitto (1998) note that perfect progressive shuns bounding time adverbials:

es María estuvo pintando la pared en dos horas. ‘Mary was painting the wall for a while in two hours.’

The English translation is not too felicitous either. Perfect progressive is a cycle, i.e. closed and irresultative, while bounding time adverbials (quod vide) prefer half closed (resultative, telic) event types.

Bertinetto/Delfitto (1998) and Johnson (1971:29, 1998), along with many other writers, exclude progressive with bounding adverbials in/by t, starring Mary was painting the wall in two hours. This seems too restrictive. There is a well known narrative construction which combines a progressive form with a bounding or location time adverbial (imparfait pittoresque), described later in the chapter on discourse.

Where’s Mr Luttrell? he heard her ask. In a moment she was greeting him...

Manning shook off his early Evangelical considerations, started an active correspondence with Newman, and was soon working for the new cause.

It is true that this combination is special, not equivalent to Mary painted the wall in two hours, simply because (prog e) in t does not entail e in t. Instead, its meaning is the expected composition of the meanings of the progressive and the adverbial, as it ought to be. The opposite scoping prog (e in t) is also unusual, but not excluded: Spasski was winning the game within the appointed time when he made a fatal move. The composition is not inconsistent (empty), only such situations are hard to verify.

A progressive imperative is uncommon in English (outside Irish English, Curme 1931:380, Poutsma 1924:67, Matthews 1989) as well as many other languages (Bertinetto/Ebert/de Groot 1998). An order concerns what is going to happen, not what is already happening, for that cannot be changed. Thus the event type licensing an imperative study is (now<\{t~study\} study). In other words, start or
keep studying, not be studying now. An interesting exception that confirms the rule comes from Poutsma. The heroine does not know what the hero is thinking about, and makes a silent wish concerning what is already happening:

I hope you’re thinking about me. Please, be thinking about me. (Webster)

This explanation predicts that progressive imperative sounds better if the order concerns a state of affairs timed by another event: don’t be watching TV when I get back. As get/keep studying shows, it is the be part of be studying that causes the problem. A causative make sure you are studying corrects the situation. Imperfective imperatives in general are fine when they can mean get/go on Ving. See section on imperfective combinatorics for examples.

**Perfect**

Perfect is variously called a tense (Frawley 1992), an aspect (Friedrich 1974) or a phase (Joos 1967). According to Paul (1886:273) "Das Charakteristische des Perf. im Gegensatz zu Aor. und Imperf. liegt darin, dass es das Verhältnis eines Vorganges zur Gegenwart ausdrückt." In the same vein, Lindstedt (1996) cites Maslov’s definition of perfect “expressing a present state as a result of a preceding action or change, and/or expressing a past action, event or state that is somehow important to the present and is considered from the present point of view, detached from other past facts”. According to Bauer (1970:190), “the action is viewed, not as a past event, but as an accomplished fact at the moment of speaking, having taken place, once or repeatedly, within a span of time that is not conceived as separated from the moment of speaking.” According to Joos (1967:140), in the perfect phase the event is not mentioned for its own sake but for the sake of its consequences. This is why it cannot be used for narratives, which present past events for their own sake. As these descriptions suggest, perfect is a complex or compositional aspect (Cohen 1989) in that it separates reference time from event time. In this context, ‘event time’ and ‘reference time’ and refer to subevents of the complex event type composed by perfect, specifically the input and output event types of the aspect.

**perf ≠rr r of e:e**

Perfect is a prototypical category of closely related variants, straddling the open-closed event type distinction, denoting some part of a final change involved in the event e. A number of typologically significant special cases of the perfect have been distinguished (cf. Bybee et al 1994). A first division can be made between resultative perfects e\(\bar{r}\)r (cf. Bybee et al. 1994 *resultive*) which produce open event types, and anterior perfects e r (cf. Bybee et. al 1994 *anterior*) which produce closed event types. A further division can be made between near perfects e r where event time extends up to now and remote ones e< r where it ends earlier (while reference time remains an extended now).

**Resultative**

A resultative\(^{85}\) e\(\cap\neq r\)r:e, denotes the final or result state (suffix) r:e\(\cap\r:o\) of an event e. This makes it a denotational variant of extended now e\(\cap\r:o\).

**res e\|r:e**

An example is English *He is gone, the glass is broken*. Resultative perfect is idempotent: e\(\bar{r}\)r.e\|r:e \(\subseteq\) e\(\bar{r}\)r. As an open event type, the resultative allows still: *He is still gone* is fine, *He has still gone* is not (Dahl 1985:133-135). Another concomitant is since (Johanson 1998:§8.5.1.1): de Er ist seit gestern verhaftet ‘he has been arrested since yesterday’. The resultative entails that the result state holds at reference time: *He is gone* implies *he is away*. A result state perfect cannot be undone: *He is gone and come back* is inconsistent (compare he has gone and come back).

What the result r is in each case depends on aspect type. For a change, the result is a state following the change. In the simplest case, this is the final state that lexically defines the change, for instance be open

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\(^{84}\) The choice is likely to depend on morphology, in particular the presence or absence of infinitival perfects in the language. Finnish reference grammars for instance only recognise finite perfect tenses. Other names suggested for the perfect are anterior (Reichenbach 1947, Bybee 1985) and absolute-relative tense (Comrie 1985).

\(^{85}\) For terminology, cf. Nedjalkov (1988:5ff). In my usage, the noun resultative refers to a variety of perfect, i.e. a grammatical aspect, while the adjective resultative is an aspect feature, the characteristic property of half-closed event types (changes). This is only a difference of focus, for a resultative perfect denotes the final state of a resultative event type.)
is the result state of open. This is the garden variety of resultativity (telicity) discussed in the section on resultativity.

Result perfect of an open event type does not change event type. The suffix of an open event, by definition, is the event itself \( \text{a} \). This makes them somewhat redundant, but not nonexistent. Perfects of open events are known in Classical Greek grammar as perfecta intensiva (Kühner 1899:§384.4), because they as it were only intensify the present (denote continued open events). Examples: dedorka 'look' from derkomai 'look'; kekhaira 'rejoice' from khauro 'rejoice'; elopa 'be in the hope' from elpo 'hope'. Johanson (1998:§10.3.2) cites examples from other languages. Another way of looking at a result perfect of an open event type is as the result perfect of the corresponding initial change (Kühner ibid). But this is a distinction without a difference.

This is what Aristotle (Met. 1048b:18-34, Eth. Nic.1174a14-b14) had in mind in saying that the end (telos) of an activity (energeia) is the activity itself. For it follows from this definition that an activity has reached its result as soon as it has come about. This in turn is indeed one of the criteria Vendler (following Ryle who cites Aristotle) lists for activities. This is also why open events are irresultative: the result implies no change, as it is identical to the initial state. The perfect of an open event holds as soon as the event has started. Or as Langacker (1982:280) puts it: the perfect derives a state from a process by focusing on the point at which the trajectory is fully instantiated, which in the case of closed event types is the end-point, while in open event types any point within the event meets the condition of the perfect, including the first.

A *continuative perfect* 'is still gone' found in Chinese, Lezgian, or Archi (Johanson 1998) can be formalised as \( e \). It denotes a continued stretch of the state resulting from a change. A result state perfect is like the progressive in that it does not have an inceptive reading.

In a lexicalised state perfect \( s \) such as *dead from die*, the result state no longer entails an antecedent change. The event-result relation at most applies at type level, no antecedent event token is implied to exist. *Dead matter* was never alive, *hidden variable* has never been in evidence. A state perfect is no longer a live aspect, Shakespeare’s result perfect *My wife is dead tonight* is obsolete. State perfects are common in Greek, where they get suppletive translations: *eidon/oida* ’see/know’ (more examples below). In English, as in many languages, state perfect participles produce adjectives: *closed (not open), extended (wide), impoverished (poor), decided (clear)*. State perfects do not allow modifiers relating to the event (Smith 1991:68): *The door is locked with a key* is a passive, not a state perfect (compare the *door is locked with a padlock*). More on resultatives in the section on perfect typology below.

**Current relevance**

For a cycle \( \sim s \sim s \), the result state is also the same as the initial state, so transient events such as *cough, hiccup, blink, blip, flash* (but also *take a nap/walk, watch some TV, visit*) are irresultative, produce no change. This is one case where *closed* does not equal *resultative*. The perfect of an open event type can denote the *aftermath* of the state (Hirtle 1975), i.e. time following a cycle of the state (*I have slept*).

There is, finally, a weak but undeniable sense in which *every* event produces a result, and that is the historical result of the event itself being past, having happened. This sense comes about from the equivalence (noted above) of any individual (hence closed) event with a cycle of itself: \( b \) is equivalent to \( \sim b \). On a coarser granularity, any event \( e \) is a turning point, a historical change, the boundary between time without it and time with it: \( \sim(e\sim)\). (the event changes from nonpast to past) or \( (e\sim)\sim \) (event changes from future to nonfuture) or \( \sim(e\sim)\). (the event changes from nonexistent to existent). These are all a half closed event types. Thus one result of any event \( e \) is its *history* or perfective perfect perf pf \( e \equiv e \). In other words, an existential present perfect of \( e \), or \( \langle e \rangle \) is also the near perfect \( (e\sim)\). An existential perfect becomes a result perfect on a coarser resolution where intervening events map to null.

A part of the grammaticalisation of a perfect is that the change \( \sim \) may become only a contextual consequence of a particular *token* of the given type rather than inherent to the lexical event type. For instance we *have met* can imply there is no need to introduce us. This is why the implicature of current (or present) relevance (Dahl/Hedin 1998) associated with the perfect is so elusive: what constitutes the relevant result depends on context (Löbner 1988:178-179). Another reason is granularity. *Paul has finished writing his part of the book* (Chung/Timberlake 1985) may mean that the part has just been finished but that he is still free to do other things - he has not started any other project of the same sort since then. Immediacy is subject to granularity.

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86 A vestige of the change meaning can still be felt: *impooverished* means ‘poorer than it should be’.
The point of current relevance is that even an existential perfect denotes a result state, namely the state that an event of the type has (not) happened. This is result enough for many purposes, for instance criminal courts and the Guinness book of records. Lindstedt (1998) makes a distinction between material bound (lexical result entailment) and temporal bound (sufficient for current relevance). Löbner (1988:178) allows a derived event type ‘event e has happened’. Palmer (1974,1987:§3.3.2.) speaks of ‘nil results’. See also Chung/Timberlake (1985).

**Anterior**

The term anterior (Reichenbach 1947) is a cover term for two closely related perfect types, near perfect and remote perfect. A near perfect is the event type $(e \cap ¬r) r'$ or equivalently $e' (¬e \cap r)$ which denotes a state $r$ immediately following $e$. If $r$ is equal to $¬e$, the formula reduces to $e' ¬e$. If $r$ is now, it reduces to $e' now$.

For open events, one difference between present resultative $anow$ and near present perfect $a now$ concerns whether the event covers the present, i.e. whether it is entailed or just implicated to hold now. Ehrich/Vater (1989) note that German perfect *Ich habe seit drei Jahren nicht mehr geraucht* ‘I have not smoked in three years’ $¬\text{smoke} (\cap 3 \text{years} \cap r) now$ is consistent with smoking at present, while extended present *Seit drei Jahren rauche ich nicht mehr* $¬\text{smoke} (\cap 3 \text{years} \cap now)$ is not.

Hirtle (1975:35-36,68) argues the English present perfect of a state does not entail that the state covers the present, for otherwise the following sentence would be redundant:

\[ \text{Change has been, and is, the breath of our existence and the condition of our growth.} \]

(Kruisinga 1931:405)

By Gabbay and Moravcsik (1980:76) even the perfect of a progressive *He has been reading his book* is true if he was reading only until now. The progressive fails to guarantee that the reading event continues now. The progressive does help suggesting it, especially in contrast to *He has read his book* which is closed. Mittwoch (1988) points out that bare activities seem infelicitous in the English present perfect, or rather, that they are coerced to closed events in the perfect. To say that an unfinished bit of activity has occurred, the perfect progressive is preferred (the progressive implicates iteration here, Hirtle 1975:§3.5.5).

John has run (away)/been running (around).

McCoad (1978) notes that *At the moment he has been away* is rather bad, but gets better with *At the moment, he has been away for a week*. Without a bound, the perfect is vacuous, for an open perfect is true as soon as (i.e. all the while) the present is. A punctual adverbial is still somewhat awkward. (By) *now/so far, he has been away for a week* sound much better (Comrie 1985:33-34).

It is only when we are marking a record (the first point when a result is reached) that the exact timing makes a difference. *Now I have met him* is appropriate right after I met him, not years later. This is sensitive to resolution. *I have met him today* is no news unless I met him today. *Today Asimov has written over three hundred books* does not require that Asimow wrote them today, not even that he wrote anything recently, as long as he is alive. (Kuhn 1989:537).

*I have always liked opera* has a strong implicature of continuation, *I have liked opera so far* is noncommittal, while *I had always liked opera until now* strongly suggests (but does not entail) a change of mind. Once the event has been over for some time, it is too late to use anterior present perfect:

A person has just been rescued from a remote island where he had/?has been marooned since 1960. (McCawley 1971:109)

A near or ‘hot news’ perfect of a change $e = ¬r r'$ has the form $¬r r'$. It denotes the final state immediately following the change. Since it holds of the immediate consequent state, it is used for hot news: *He has just/gone* is true at a time immediately after the departure. An anterior perfect of a closed event is closed from the past so $¬r r' r'$ is not of type $¬r r'$ but an iteration of that type. Hence closed near perfect allows already and just but not still. *He has already left* is fine but in *He has still left*, leave is coerced to an iteration (Hirtle 1975:81fn,93, Hoepelman/Rohrer 1981:114, Dahl 1985:134, Nedyalkov and Jaxontov 1988, Bybee et al. 1994:65). Lindstedt (19???) observes the same restriction on the Finnish perfect. Compare

The patient cannot go out because she has still only recently recovered from an illness.

Hot news (McCawley 1971, Comrie 1976:60, Anderson 1982) is a context for closed near perfect (Johanson 1998:§8.5.2). News is hot if the event is recent, in fact immediate: it is the *latest* news about
the matter at hand. As always, immediacy, adjacency of events, is relative to resolution: what matters is that no other event of the same scale and granularity intervenes. Johanson (1998:§5.2.1) observes that Balkan languages with an existential perfect tend to use a perfective past here.

Now tell me, what news of the mission? - We have located the ship. - Wonderful, said Halfrunt, wonderful! (Adams: The Hitch Hiker’s Guide to the Galaxy).

Temporal adverbials with near perfects denote an extended now <now like today or this week. The since clause denotes an extended now in Since you have been here, everything has been fine denotes here\fine<now. Proper past adverbials like yesterday, last year or before, previously are excluded. My father has died is hot news, My father has died in the past is unlikely. Compare a father of mine is dead or people have died in the past.

Mittwoch (1988:247) notes that Today John has done his homework. is ambiguous about whether John did (all) the work today: homework\today\rf\now vs. homework\rf\today\now. The former is equivalent to a near past homework\today\now Only the latter reading remains for I have been here for a week today here\week\rf\today, for obviously the past week won’t fit within today. Yesterday is no good on either scoping: Yesterday John has done his homework homework\rf\yesterday\now and homework\rf\yesterday\now are both empty.

Durative adverbials can measure the result state with an anterior perfect. He had gone out for 20 minutes translates as ¬away\away\20min\now where 20 minutes measure time from departure (some of it, even all of it, may still be ahead). The imperfective paradox applies, making the estimate a subjective one, measuring planned absence. In past perfect both interpretations are possible: He had gone out for 20 minutes and returned/but never returned/returned early.

Existential perfect

A remote or existential (experiential, indefinite) perfect e<\r:e just says an event has occurred sometime in the past.\footnote{A possible (but unlikely) variant is existential resultative e\rf\ equivalent to an inclusive past e\leq r.} This trivial result state of the existential perfect never ends (what has happened cannot be undone), so existential perfect is irreversible (Galton 1984:58) or irreversible (Nedjalkov 1988).\footnote{In generalised quantifier terms, existentials are upward persistent, which makes existential perfect forward persistent.} A formal reflex of this is that the following event type denotes I:

\[(e<\now) \cap (\now\leq e<\rf) = e<\now) \text{ ‘What happened will have happened’}.
\]

The perfect of an irreversible state is awkward: Napoleon has been dead (Klein 1994:101). This is odd, because has been dead implies is dead. A measure phrase adds a later bound and saves the sentence: Napoleon has long been dead. An experiential perfect sensu stricto is an agentive existential perfect (Lindstedt 1998).

Existential perfect is odd with still. As Hoepelman and Rohrer (1981:114) point out, irrevocability makes still redundant. He has still left would implicate having left could stop, which is not possible. Adverbials of duration are odd in general:

I have been alive/\#born for 47 years today.
Our family has been in/\#to Wales for a month now.
We are/\#have got up since dawn today.

The constraint already follows from the representation of existential perfect. Consider two candidate formalisations of I have been born for 47 years today:

\[(\neg \text{born.born\rf\year})^{47} \text{\today}\]
\[(\neg \text{born.born<\rf\year})^{47} \text{\today}\]

The first formula makes for 47 years an event time adverb, implying multiple days of birth. The second formula construes it as a reference time adverbial, cramming 47 years into one day. Even a shorter adverbial like since dawn is odd, much as the simple present tense is. All in all, reference time as an event type has a weak existence in anterior perfects: it either coincides with event time (near perfect) or is unbounded (remote perfect).

The event time e of an existential perfect is properly past, so it allows remote event time adverbials. Example: fi Hän on käynyt tiellä viime viikolla ‘He has been here last week’. It has been observed in many languages that with a definite remote past event time adverbial existential perfect becomes
evidential. Finnish *Eilen olen ollut sairasta* ‘Yesterday I have been ill’ is unlikely, for I ought to know my past condition by acquaintance. The best interpretation is that I was unconscious yesterday.

Kuhn (1989:537) finds it hard to reconcile the idea of perfect as a near past to the fact that the event can be remote. Why should one ever say *I have bought a pair of shoes* outside a shoe store, or *I have lived in Finland* when I am very obviously living in Germany? Simple: in the existential perfect event type \( e < r \), the event \( e \) is remote, but the reference time \( e < \) is near.

Indefinite existential perfect is a dual of a habitual or iterative one. Existential perfect is particularly common in negative polarity contexts, for that is where the weak side of the duality turns up. Compare for instance

- Have you ever helped him when he has been ill?
- No. I have never helped him when he has been ill.
- Yes, I have helped him when he has been ill.

The positive answer can be understood as the contradictory or as the contrary of the negative one.

**Perfect combinatorics**

The perfect has no imperative: *Have studied, have not watched TV*. Bad timing (one cannot change the past) is only a part of the explanation. *Have studied when I get back* avoids that problem but is not much better, though the idea can be expressed by adding a causative *Make sure you have studied when I get back*. (This is much preferred with the progressive imperative too: *Make sure you are studying when I get back*). As the paraphrase shows, the other half of the explanation is that the perfect is a state and states are incompatible with the imperative, because the subject is not an agent. The progressive is better than the perfect, being a dynamic state.

Conversely, there is no progressive perfect in English (Mittwoch 1988:243) because having done something is a simple state.99

I am nearly having written this paper.

Hirtle (1975:41) notes that the perfect does not get iterated either: *Have you always got this much rain in Quebec?* (parf have) is an odd way to ask *do you always have/get (pf? have)*. Perfect does not get iterated because it is irrevocable (Galton 1984): it won’t cycle because it never ends. A bound perfect is fine, because it is the main event that cycles: *Whenever I see them they have been swimming* (see → perf swim). And of course the sentence makes sense as the perfect of an iteration: *We have always got this much rain in Quebec so far* (parf have).

Smith (1991:111) considers perfect a special case of perfective. Though this may be a fair description of closed perfects, it hardly fits open perfects.

Because a perfect denotes a state, the unmarked morphology for perfect is adjectival, usually a result participle. Finite perfects get formed by combining an auxiliary - usually be or a posture verb with an active participle or have with a passive participle. The participle is perfective or a perfect. The voice of the participle depends on transitivity and the auxiliary depends on voice in ways that are predictable (compositional) until grammaticalisation sets in. The Finnish and Bulgarian perfects have be plus an active participle, the Portuguese and English ones have have plus a passive one. Some languages mix both types (German). The Russian preterit is an old active participle that has lost its auxiliary. Agglutination pastes together finite inflected perfects from periphrastic ones. (Johanson 1998:§8.8.)

The English perfect as a rule does not go with future time adverbials like *tomorrow, next week, a week from now* (Crystal 1966, Matthews 1987:145). A case in point would be a scheduled future perfect like *The last plane on Sunday has landed well before the last train leaves*. (This is a constructed example; I have not attested such usage naturally.) A non-case are result state adverbials like *I have turned off the heating for tomorrow/until further notice*.

**Generic aspect**

Consider temporal generics in particular. A generic sentence like *he (generally) smokes* should thus be analysed as a generic quantifier R over smoking occasions can and smoking occurrences smoke. (I leave the restriction to smoking occasions out where it becomes vacuous.)

\[
\text{can Q smoke}
\]

---

99Hirtle (1975:26-27): “[Perfect] constitutes an event which can never suffer any development or change, a fact which explains why it is not possible to have the progressive [perfect]”.

The upper limit of $Q$ is always: *He always smokes (when he can)*. This is the special case smoke or can→smoke discussed in the previous section. The lower limit is sometimes: *He sometimes smokes* can be expressed as ¬smoke or <smoke<.

Then there are the cases in between. One class are relative frequency adverbials *He smokes twice a day of form (pf smoke) twice (fday)* of which *many times a day, often/frequently, regularly, every now and then* smoke are vague representatives.

Another significant special case is mostly, which says that more smoking occasions are smoking occurrences than not: *[can]¬[smoke] > [can]¬[smoke].* (Here the greater than sign compares the number or duration of occasions, not temporal order.)

Counterfactual generics work the same way. The difference is that the generality extends from actual to merely possible occasions. *He usually, habitually, typically, normally smokes* have such counterfactual implications, i.e. involve considerations what *would* happen if things were in a way which they may never be. They differ in what kinds of modifications to the status quo are admissible in each case. The deductions what would happen depend on what other generic event types, invariants, regularities or laws, must be kept unchanged in moving from one situation to another.

I abbreviate the two-place generic operator can $Q$ smoke as a one-place operator gen smoke (which leaves the domain of restriction of the generic quantifier implicit). It covers habits and dispositions as special cases, discussed in the next section. The generalised quantifier format $pQq$ where $Q$ is a binary relation on a Boolean algebra nicely brings out the two degrees of freedom in narrowing down generics: intensionally by qualifying conditions $p$ on the domain and extensionally by quantitative constraints $Q$ on the generalisation. Both are involved in spelling out examples like G. Carlson’s *Lions have manes* as *most adult male lions have manes*.

The generalised quantifier point of view also puts my earlier observations about *always* in sharper focus.:

Mary always sleeps.
Mary only sleeps.
Mary always sleeps well.
Mary only sleeps well.
Mary never sleeps badly.
Mary mostly sleeps well.

According to the generalised quantifier analysis, a quantifier has an event type it *lives on* (can) and the one it *quantifies* (smoke), related as presupposition and assertion or focus. If the presupposition is empty, we approach a categorical quantification: *Mary always sleeps (when she can)* becomes can→sleep or just sleep, which (if we restrict the range of only to sleep∪¬sleep) equals *Mary only sleeps*. If the sentence has a natural division into focus and presupposition, that can be used, so *Mary always sleeps well becomes sleep→well*, which is practically equivalent to *Mary only sleeps well*. This choice of focus also explains why *Mary never sleeps badly ¬(sleep)badly* seems to mean very much the same. Similar observations apply to *Mary mostly sleeps well*, whose first reading (though not the only one) is that most of Mary’s sleep is good.

A generic quantifier over occasions is in effect an unspecified frequency adverbial (Vlach 1993). It thus makes it patent why generics have a close affinity to sentences with explicit frequency quantifiers like *Every afternoon John ate and apple, Eva got up at noon last summer* (Smith 1991:41). It also follows that generics produce open event types (in fact, states).

**Regularity**

An event type is *almost periodic* if there is a partition of time into periods in each member of which there is a token of that event type. The partition constitutes a convex hull of the sequence of events which envelopes the tokens of the event type.

The strength of a claim of almost periodicity depends on the character of the partition. In the degenerate case, any event is almost periodic with period one, in the envelope of eternity. A timeless event is almost periodic relative to the discrete topology. A habit is an almost periodic event which happens every now and then. A disposition is one which happens always on given conditions.

The above definition of almost periodicity can be recursively reapplied to itself by noting that the almost periodic event type may itself in turn be almost periodic on some yet finer event type. Periodicity is thus a case of granularity.
Extensionally, an almost periodic event happens in a given fraction of the members of the partition, when the cycle of the independent variable does not correlate with the period of the dependent variable. Depending on the choice of the independent variable, different statistical probability estimates may be obtained.

Intensionally, a better match may be approached by refining the rule for picking out the partition. The relevant notion here is one of a general rule leaving exceptions which in turn fall under a minor rule, perhaps again with exceptions. For instance, the fact that the solar year does not fit the calendar year is solved by the Gregorian rule for leap years, which is typical a rule with exceptions:

The leap year is every fourth year; but there is no leap year at even hundreds of years; but there is one at even four hundreds.

What kind of a rule is this? Well, it is a strategy. The general rule is followed until it fails, in which case the exception is taken, until taking the exception again causes an error, in which case an exception is taken to the exception. This is a typical preferential, approximative, or fractal process.

This analysis of regularity ties up with my analysis of genericity in terms of granularity. It also ties up with an analysis of causation as default reasoning. My analysis of causation is also predicated on the notion of a strategy. It reflects the observation by philosophers of science that causal explanations are ceteris paribus explanations: what needs explaining is a deviation from a general rule. The explanation is a minor rule which allows for the exception.

Take for instance what it means to say I teach on Tuesdays. It does not quite have to mean I play every Tuesday, although it certainly is entailed by that. What it means that as a rule, I teach on Tuesdays. Exceptions are allowed, especially if there is a minor rule covering the exceptions: except every third Tuesday when there is a faculty meeting. That exception again may have exceptions, and so on. These ideas naturally lead up to Fourier transformations.

Adverbs like regularly, usually can be given a semantics using these ideas. What they say is that there is a rule (possibly a strategy, i.e. a preferential rule with built in exceptions) which governs an almost periodic sequence of events of the given type.

**Habits and dispositions**

Habits and dispositions can be construed as dual reducts of the notion of an almost periodic event type. Dispositions (Palmer’s potential verbs of state, 1987§4.3.1,4.6.1) support predictions (counterfactuals concerning outcomes of experiments, i.e. closed events). An absolute disposition denotes a timeless property which under certain counterfactual conditions triggers a closed event. In other words, it asserts the existence of a strategy \( \sigma \) which in a quantity \( Q \) of cases produces \( e \) under conditions \( c \) in situation \( w \):

\[
\text{disp: } c \sigma wQe
\]

A generic disposition is thus a counterfactual generalised quantifier that turns a closed event into a state of vague generality: ‘there are conditions \( \sigma \) under which generally (sometimes, often, mostly, always, usually when \( q \)) \( b \)’ A disposition is a conjunction of conditionals: He smokes in the bathroom ‘whenever he smokes it is in the bathroom/whenever he is in the bathroom he smokes’.

Dispositions don’t entail occurrences. A glass can be brittle and never break. One does not ask how often but how easily it happens. Because of genericity, a glass need not necessarily break when it is dropped, only it is liable to do so.

Higher order iteration \( pt^* \) which produces series was already mentioned as an implicit aspect shift in English. Through counterfactual generic quantification, a series becomes a habit, which turns it into a dynamic state (Vlach 1993:241). In habits, an event type \( e \) is iterated, allowing for gaps of some unspecified event type \( q \).

\[
\text{hab: } \neg \text{disp} \neg
\]

A habit is the dual of a disposition. This turns an open event into a counterfactual state of vague generality and counterfactual import: ‘Conditions \( c \) cause that generally (sometimes, often, mostly, always, usually) when \( q \) \( a \)’. Though a habit does not imply any particular instance at the time of reference, it (even counterfactually) entails a series of instances around it. Habits have existence entailments: It is not possible to have a habit of doing something and never do it. This follows because the range of contexts \( c \) includes the actual context.
One common way to put this is to say that genericity turns events into properties of individuals. If one thinks what it means to ascribe an event type as a property to an individual, it seems to imply that the event type is made part of the individual concept of that individual, and is thus less apt to be removed from the set of premises concerning that individual when varying counterfactual situations involving it. Maigret smokes a pipe in all of Simenon’s books, but he only eats in one of them. Another facet of the same observation is that assigning an event type involving several individuals as a property of one of them is a question of explanatory value, of efficacy in classifying facts. If you and I often get to a fight, at least one of us is irritable. Which one of us it depends on which grouping of incidents is a better index to them.

An open event type a turns into a habit through higher order iterations pf"a. One might characterise a habit as a dynamic state whose sustaining process is a series. This is why habits take considerable time, are not naturally attributed to the immediate here and now (Kucera 1981), but allow the progressive. Logically, a habit is a join of meets: He smokes in the bathroom. ‘there are several instances of his being in the bathroom and smoking, if not today, then tomorrow or next week’. It makes sense to ask how often someone habitually smokes (Kasher and Manor 1980).

Random repetitive event types like smoke or collect stamps are prime habits. Predictable once-only event types (like brittle or flammable) are prime dispositions. The limiting case of both habits and dispositions is a regularity: The sun rises from the east is fully predictable both ways.

Habits and dispositions are dual ways of looking at a generalisation, extensional (by instances) and intensional (by rules). As modalities, habits are universal-existent (inability type) modalities, and dispositions existential-universal (ability type) modalities. One who habitually smokes must let it happen sometime, i.e. cannot always prevent it, one who dispositionally speaks English can bring it about anytime, i.e. will always be able to do it. Habits happen every now and then, dispositions happen any time in given conditions. A habit has a frequency: it is instantiated at least once in every period of sufficient length, a disposition has conditions: it is realised every time in at least one type of situation.

The reason why the duality, in fact the difference, between habits and dispositions is easily lost is that they involve generic quantification, i.e. their quantifier character is vague. A weak disposition is a prime habits. Predictable once-only event types (like brittle or flammable) are prime dispositions. The limiting case of both habits and dispositions is a regularity: The sun rises from the east is fully predictable both ways.

An illustration of the duality comes from game theory. Take a two-person zero-sum game of perfect information, say sequential version of Left or Right, where players Left or Right choose a hand in turn and Left wins if the choices are different). The second player always wins (can always win) in the dispositional sense: there is a strategy which wins against all opponent strategies. But in a simultaneous version of the same game, where players have to choose numbers independently, neither player can win. In iterations of the game, both Left and Right keep winning and losing in a habitual sense: there is no way to guess which. This is an instance of actual iteration backed up by a counterfactual theory.

Once the duality of habits and abilities is noticed, indications of it are easy to find. Habits are easy to develop but hard to break, while abilities are hard to acquire but easy to lose. We are slaves of our habits while abilities are power. We try to shake bad habits and gain useful abilities. There are collocations like habitual criminal and capable officer. Ryle (1949:43) explains a disposition such as brittleness as ‘bound (liable) to undergo a change when a condition is realised’, and his habit of smoking as ‘permanent proneness to smoke when I am not eating, sleeping, lecturing, or attending funerals, and have not quite recently been smoking’. Thus one can predict of a disposition when it will happen, of a habit (at best) when it does not. A glass breaks if something makes it. Ryle smokes unless something stops him. Habits tend to be passive (they are succumbed to) and abilities agentive (they are exercised). Etymologically, habit and ability come from the same stem habere ‘have’: habitus is a passive perfect form, habilis is an active future one.

Belief is a habit but knowledge is a capacity. We make people believe things but let them know things. Belief is something one holds and clings to, knowledge is something that one acquires and applies.

Further evidence of the analysis of habits and dispositions as duals is that some languages use different aspects for habits and dispositions (imperfective for habits, perfective for dispositions). The habit describes what tends to happen without specifying when, and the disposition what will happen in given conditions (Hedin 1998). Examples:

Prosto zahodit muzyku poslushat’. Sjadjet v ugol, poslushajet chasok - i domoi. ‘He simply drops by to listen to music. He will sit in a corner, listen for a while and home (he goes)’.

On vsegda najdet/nahodit vyhod. ‘He will always find/always tends to find a solution’.

Il lisait/lit toujours une heure après le petit déjeuner. ‘He (would) always read for an hour after breakfast.'
Ele sempre faz(ia) os deveres.’ ‘He always did/would do his homework.’

Simonides kantoi aina kaiken omansa/kaikkea omaansa mukanaan.’ Simonides always carried (took/lugged) everything (part/nom) he owned with him.

English uses will to signal nonpast disposition (not habit). Would can mark a past habit or disposition. Used to can report a remote closed habit in the past **hab e « now**. This does not entail the habit is over; as usual, it is enough for the reference time to be over: He used to smoke a lot when I knew him. - He no longer/still does**50**. Used to is paraphrased I had the habit of (remote past), not I have had the habit of (near past). Would needs a reference time to hang on to and so cannot start a topic, used to doesn’t and can. Further tests to distinguish between habit and disposition come from negative polarity quantifiers like any. These only occur where they can have marked scope, i.e. with weak connectives, quantifiers, modalities and negation. They disambiguate for disposition:

He would defy everybody, go everywhere and do everything (habit).
He would defy anybody, go anywhere and do anything (disposition).

Habituals come from iteratives (but not conversely) and from habitual and dispositional verbs (live, know how, be used to). Dispositions come from futures and (other) agentive modalities (Bybee 1994:159). Czech (Kucera 1981) has a suffixal iterative aspect in -ava specialised to habitual-dispositional meaning. Typical examples are

Nemci mluvivaví spatne cesky ‘Germans tend to speak Czech badly (i.e. of those Germans who speak Czech, the majority speak it badly).’
Rusti generalove umiravaji vmladem veku ‘Russian generals tend to die young.’
Petr mi psaval ‘Petr used to write to me.’
Znaval jsem ho dobre. ‘I used to know him well.’

Habitual aspect is excluded from progressive contexts:

Kdyz jsem vesel do pokoje, Petr hraval na klavi. ‘When I entered (pf) the room, Peter used to play the piano’.
Budy vas cekavat zitra v sedm hodin vecer. ‘I will (usually) wait for you tomorrow at seven in the evening.’

This recalls the awkwardness of John sleeps in his office frequently today/right now. The only present time adverbials that are really felicitous with generics are of vague duration, like now or these days.

Smith (1991:40) notes a typological tendency of perfective sentences in the present tense to signify generic aspect. This tendency is future prediction turned to disposition (cf. English Mary will feed the cat).

A philosophical problem: Aristotle (Nicomachean Ethics) concludes that virtue is a habit, not a passion or faculty, because it is deliberate and praised or blamed for. I have just described habits as something one cannot help having. Are these views compatible? Perhaps, taking resolution into account. An agent’s long term plan, once formed, binds him much like another agent. A habit takes time to form or break, but it can be done, given time, and motivation. That is just what praise or blame is for.

**Phasal adverbs**

Aspectual (phasal) verbs and adverbs deal with beginning, ending, continuing and repeating (Freed 1979, Harkness 1987:78, Löbner 1989,1990,1999, Mittwoch 1993, Snessaert 1997,1999, van Baar 1991, van der Auwera (ed.) 1991, van der Auwera 1993,1996). English phasal adverbs include already, still, yet, any more/longer, again, only, just. Phasal adverbs have a presupposition or background and assertion or focus. They presuppose something about what went before and assert something about what holds now. The denial of a phasal adverb shares its presupposition: the denial of He is still here is He is already away which shares the presupposition that he was here. Löbner (1989) maps the four phasal adverbs still, not yet, already, no longer on the square of opposites formed by the four group (sU-s)**52** of simple changes

<table>
<thead>
<tr>
<th>still</th>
<th>already</th>
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**50**Joos (1967:138) describes it by saying used to matches events to the whole era, while would matches them singly to their separate occasions. Russian has colloquial habitual verbs xozhivat’, sizhyvat’ which are practically only past: ‘he used to go/sit’ Dahl 1985 lists past habitual as a cross-linguistic prototype.
Table 13

Though the mapping is revealing as far as it goes, the picture gets more complicated on a closer view (Snessaert 1998). The full picture includes that phasal adverbs are scalar adverbs (König 1977,179,1981,1991, Krifka 1997). Scalar adverbs comment the slope of correlation between two scales (Lai 1999). Since scalar adverbs relate two scales, they have several dualities, corresponding to inversions of the two scales. *Already* ‘as much as *m* as early as *t*’ has a direct dual in *still* ‘as much as *m* as late as *t*’, and double one in *only* (yet) ‘as little as *m* as early as *t*’. The fourth possibility ‘as little as *m* as early as *t*’ is exemplified by *anymore*. In addition to scalar dualities, phasal adverbs come in tight (open) and loose (closed) variants.

**Already**

*Already* is a scalar adverb meaning *as much as x as early as now*. *He is already eleven* can suggest he is unexpectedly undeveloped for his age, or that he got eleven earlier than expected. (On a scale of developmental age, his data point is above the expected curve: he is this old too soon, or too old now.)

*He is already eleven* thus means $11 \leq \text{now} < t$ or $x < 11 \leq \text{now}$.

*It is already dark* either means it has become dark earlier or it will have been dark longer than expected (darkness is ‘all ready’ by now). As a temporal adverbial, *already* suggests that an event is early. This is really only the temporal projection of the scalar implicature above. Formalisation:

$$e \preceq t$$

*Already* is a focus adverb which can focus another item in the sentence, presupposing the rest. *Already *t* where the focus* is a frame adverbial can be paraphrased with *by* *t* or *as early as* *t*. Where *m* is the correlate scale *already* *m* can be paraphrased by *as long as/as many times as/as much/many as m*. *I got up already at six* means I got up at six which was earlier than usual: up$\preceq 6 < \text{usual}$.

An implicature of *already* for open events is that the event has begun earlier. If darkness is here now earlier than expected, then has begun earlier than expected. If she is asleep now then she has already fallen asleep. It was expected to begin now, it began before now. The special case where the event extends through now can be represented by a$n \leq \text{now}$. Its dual is e$\leq \text{now}$ ‘by now’. This is how *Portuguese ja vou ‘I already come (pres)’ come$\leq \text{now}$ translates English *I am coming*. come$n \leq \text{now}$ and *Russian Ota uche dva chasa tancevajet ‘She dances (pres) already two hours’ dance$\leq 2h \leq \text{now}$ translates English *She has been dancing for two hours (in dance)$\leq 2h \leq \text{now}$*.

An apparently free occurrence of *already* is anchored too. If the reference time *t* is not given it is taken to be *now* or *then*. This explains the interplay of *already* with English (or Finnish) finite tenses: *I am already here* here$\leq \text{now}$ versus *I was already there here$\leq \text{then} < \text{now}$*. The latter type requires that the past tense has past focus (reference time) e$\preceq \text{now}$ alias e$\preceq \text{then} < \text{now}$. An indefinite or unfocused past tense e$\leq \text{now}$

$I have already lived here for three months can mean the experience is not new to me (live$\preceq 3\text{months} < \text{now} < \text{r} \leq \text{now}$ while I have lived here for already three months here$\leq 3\text{years} < \text{now} < \text{r} \leq \text{now}$ means that the stay is getting longer every day. *Already* is not interchangeable with *as long as* here. *Already*, anchored to *now*, guarantees that the event continues through the present, the unanchored as long as does not (Johanson 1998:§8.5.2.1).

Compare also Hoepelman/Rohrer’s (1981:112) *Beethoven has already written 5 symphonies*. *Already* ‘by now’ suggests symphony writing has gone on until recently and was expected to go on. Ergo *Beethoven must be alive.*

*I am already going to do it tomorrow (now$\preceq t < \text{do}\leq \text{tomorrow}$ means the decision to do it tomorrow does not need further prompting, while *I am going to do it already*(as soon as) *tomorrow now$\leq \text{do}\leq \text{tomorrow} < t$ implies tomorrow is an early date to do it*

If the expected time is in the future, it is news that the event holds now. By implicature, *already* denotes the result of a recent change from the absence of an event to its presence, specifically, the first appearance of the event. Thus *The baby already walks* can be said when the baby has just taken her first steps, and *The light (has) already changed* as soon as it has. A formalisation which covers this implicature is $a = a ? \text{a}$, which allows a recent or an immediate change.

$^{91}$A discontinuous measure adverbial like *yhteensä kolme vuotta ‘altogether three years’* still allows for gaps.
The combination of *already* with a change produces red→red.now, in effect turning the perfective into a near perfect. This is also the definition we get for *already* from its interdefinability with *not not yet* or *not still not*. It also has the desired relation to *by now*.

In other contexts, the implicature can be almost the opposite. *I have already told you what to do* does not implicate I told you recently, but that this is not the first time. *The house is already a hundred years old* does not so much stress that the anniversary came unexpectedly early, but that the house is older now than one would expect.\(^2\)

Altogether, there are three competing implicatures of *already*, discernible in

*fi* Kun tulin kotiin, vaimoni oli jo hyvin vihainen.
‘When I came home, my wife was already very angry.’

First, she was angry earlier than expected. Second, she had been angry before my arrival. Third, she had got angry not too long ago. The first implicature is an entailment: it is what *already* means. The second implicature is entailed from *already* together with the open event type of *be*. Substituting *got* for *was*, we get the meaning ‘this time she got angrier than expected.’ Here *already* comments on the degree of anger rather than its duration. Languages and contexts may choose one or another of the implicatures as the focal meaning. The third implicature (that the event is relatively recent) is weakest: it follows from assuming that our expectations were not entirely off.

Löbner (1990) argues against including (speaker’s) expectations into the truth conditions of *already*. His point is that phasal adverbs carry expectations just as much or little as (other) positive adjectives: *you are early/ late* also implicate you are earlier/later than some norm. The expectations need not be mine: *You need not tell me, I already know* rather means that I know earlier than you think. The presupposition ¬¬e in the expression ¬¬ee? e for *already* is thus not always a speaker presupposition, but the implication of change ¬¬ee can remain only hypothetical (counterfactual).

**Aspect of already**

The aspect of English *already* as a free sentential adverb is a moot question. Mittwoch (1988:241) and Vlach (1981b:68) claim *already* only accepts states (including perfect).

According to Smith (1991:243) *John had already watered the lawn yesterday* can only mean that John watered the lawn the day before. But compare

I did not water the lawn this morning because John had already watered it yesterday.

I suspect the same applies to the question marks in front of some of the examples in Bertinetto/Delfino (1998), for instance

During the maths class, Mary already played cards with John.

By Finnish standards, this ought to be fine in the context of, say, *The children did not take long to make up their quarrel*. (A state smiled at would be better than the activity played cards with.)

Mittwoch (1988:209) finds *already* in the first two of the next four examples odd, while the other two are fine. She takes this to show that *already* goes with existential perfect but not with universal perfect.

At first he commuted, but for the last three months he has already lived here.
I have already been in Boston since eight this morning.
I have already been in Boston for twelve hours.
I have already seen them twice since they got back.

Indeed, there is a difference in that the time adverbials for *the last three months* and *since eight this morning* are already anchored to *now*. In the other two, *already* decides whether *twelve hours* and *twice* abut to *now* or not.

As Mittwoch (1988:242) observes, the problematic sentences get better if *already* is anchored to the time adverbial. Then the paraphrase for *already* is not *by now* but for *as long as* or *since as early as*:

At first he commuted, but already for the last three months he has lived here.

\[ (3\text{months} \text{now}) \text{long} \] \[ r\text{now} \]
I have been in Boston already since eight this morning.

---
\(^2\)This may be how *fi* johan se tuli sieltä ends up meaning ‘There it is at last’, meaning it took long but not forever.
The proposed aspectual constraint seems too narrow for (American) English. A free (implicitly anchored) already meaning before now/then appears with all tenses and aspects, including the simple past (Bertinetto/Delfitto 1998):

Mary already painted this wall.

English and Finnish allow already/jo with simple past: fi söin jo ‘I already ate (pret)’ meaning eat<now> is acceptable alongside fi Olen jo syönyt ‘I have already eaten (pres perf)’. These languages are also similar in having definite rather than perfective past, and allowing simple past for near past events: fi Söin juuri ‘I just ate (pret)’ / Olen juuri syönyt ‘I have just eaten’. The spread of American English style I already ate or I already told you has been taken as an indication of the simple past extending to the territory of the present perfect (Johanson 1998:§11.6.1). What happens here is that the focus of the tense shifts from near past eat<now> to the present eat`now. Cyclic events like meals are a known locus for such neutralisation.

Russian and Portuguese do not distinguish between perfect and perfective past. In these languages, užhe/jà may disambiguate for present perfect sense: užhe obedal/ já comei ‘I have already eaten’ (Santos 1996:§12).

Witness also English (colloquial)

Al already showed the picture to Betty and now he showed it to Celia. Betty<now>Celia.now which orders the events Celia<Betty. Here already moves event time to a remote past. This is also how ru užhe emulates pluperfect (quod vide).


Pierre is (pres) already here. He has already eaten (pc). Pierre was (impf) already there. Mary had already left (pluperf).

but not (A ce moment-là) Pierre déjà partit. ‘Then Pierre already left (ps).’ The exception is explained if French déjà denotes a (half)open event type ¬aa?, while partit denotes a past closed event (here¬here)<now. By the same token, déjà excludes the spoken language perfective past reading of Pierre est parti, leaving only a present perfect reading. One can also work out the expected contrasts between Il est déjà/toujours été là/disparu. ‘He is has already/still been there/disappeared. All are acceptable, only Il a toujours disparu ‘he has always/still disappeared.’ is iterative.

German schon seems to prefer the perfect unless it is associated with another adverbial (Hoepelman and Rohrer 1981):

Die Bombe hat schon explodiert / explodierte schon/am elf. ‘The bomb has already exploded / exploded already at a remote past.

Other phasal adverbs

Already and still are dual: still equals not already not. Still thus denotes events which continue past their expected term. The event is a point above a descending curve: as much as m as late as t., later than expected or more than expected at the time.

Still denotes noninitial sections of open event types and again noninitial occurrences of closed events (Matthews 1987:154). Still and again are topologically dual: still means more time/longer and again means more times/another time. Again can count changes or their result states: The rocket entered the atmosphere again can mean the rocket entered atmosphere another time or that it re-entered it (was there another time), i.e. it can be represented as ¬air?.air.¬air.air.

Yet is a negative polarity companion of already: not yet equals not already. Anymore is a negative polarity version of still: not anymore equals not still. Both anymore and yet occur in positive sentences with negative implication (anymore is nonstandard here).

We have yet to implement any of these analyses within Montague’s framework. (= We have not yet...)

He is out of job anymore. (= He has no job anymore).
In English, as predicted, still is noncount and accepts open event types while again counts closed ones. Italian ancora and Spanish todavía 'once more; still, again' are unmarked for aspect (Bertinetto/Delfitto 1998):

italian: Maria ballava/ballò ancora la polka. 'Maria was still dancing polka / danced a polka again.'
espanish: María bailaba/bailó todavía la polka. 'María was still dancing polka / danced a polka again.'

German noch (Hoepelman/Rohrer 1981) and Finnish vielä 'still,yet' accommodate both open and closed event types, while immer noch/yhä vielä 'still' vs. noch mal/vielä kerran 'once more' and wieder/taas 'again' make the difference.

fi Kynttilä palaa yhä (vielä). de Die Kerze brinnt immer noch. 'The candle is still burning.'
fi Kerro vielä kerran (= taas) satu. de Erzähl uns noch mal (= wieder) ein Märchen. 'tell us a story once more (= again).'

Like German noch or Finnish vielä, English yet also appears as a closed variant of still meaning 'yet another time, sooner or later, eventually':

She will leave you yet.

There are a few less obvious uses of noch/vielä as well as their negations nicht mehr/enää with closed event types (Hoepelman/Rohrer 1981:126fn):

fi Teen sen vielä tänään de Ich mache es heute noch 'I’ll do it still today.'
fi Hän tulee vielä. de Er kommt noch. 'He will come eventually.'
fi Ei hän enää tule. de Er kommt nicht mehr. 'He isn’t coming any longer (we can stop waiting).'

These uses do not entail the same event happened earlier. All noch/vielä imply that something went on previously, i.e. the event is an increment, an addition to something else.

fi Maigret joi vielä lasillisien Calvadosia. de Maigret trank noch ein Glas Calvados. 'Maigret drank an additional glass of Calvados/Maigret additionally drank a glass of Calvados.'

Accordingly, the semantics of German/Finnish noch/vielä is rather `e ‘first something and then e’.

This matches nicely the problem cases above: noch heute is `e/heute, i.e. the event happens at a time which is ‘later today but still today’. It is not the event but the day that goes on later than expected. The eventual future sense is transparently represented by `e in branching time: an eventual event is one which may happen arbitrarily late but still happens (in every possible future there is a time when it happens). The enää/nicht mehr/any longer example is the contrary of eventual future: the absence has become certain, there are no more possible futures left where the event happens.

The continuation implicatures of already/still are patent in the next examples. Without already, the man might have stopped chasing women on becoming a father; with it, the suggestion is the one expressed in the second example.

He was chasing women already before you were born. chase\_born\_chase
He was still chasing women after you were born. chase\_born\_chase

The focus adverbs only and just have an espectual use as late/little as: He (has) just arrived/He arrived only yesterday disambiguates for immediate past. The logic: arriving is the only thing there has been time for, nothing else has happened between then and now.

Finnish and German have phasal adverbs for ‘as little as m as late as t’, denoting points below an ascending curve. fi vasta eilen/de erst gestern. ‘only/as late as yesterday’, vasta kerran/erst einmal ‘only as little as once’. Examples (Duden 1989); de Ich habe ihm erst gestern gesprochen. ‘I spoke to him only yesterday’, er ist erst zehn Jahre alt ‘He is only ten years old’. Anchored to the verb, this adverb thus means 'only (just)': Die vorstellung hat (eben) erst begonnen / fi Esitys on vasta (juuri) alkanut 'The presentation has only just begun'.

Though not exclusively scalar or phasal, English Only\_just (yet), translate fi vasta, de erst, e.g. de Sie ist erst elf / fi Hän on vasta yksitoista 'She is only/just eleven (yet). Finnish positive polarity, vasta is paired up with edes (not) as much as m as late as t, which translates German erst in negative environments: Er hat nicht erst begonnen / Hän ei ole edes aloittanut 'He has not even started'. Without the not, it means 'at least, anyway': Hän on edes aloittanut 'He has at least started.'

Here is a tabulation of some English phasal adverbs. English still is tight, yet and already are loose. Yet and anymore are negative polarity items. Finnish yhä is an open positive polarity still, paired up with
negative polarity *enää 'anymore' which, like its English counterpart, also appears without explicit negation meaning 'as little as m as late as t'.

<table>
<thead>
<tr>
<th>adverb</th>
<th>event type</th>
<th>tight</th>
<th>loose</th>
</tr>
</thead>
<tbody>
<tr>
<td>still</td>
<td>a`a</td>
<td>t≤∩a</td>
<td>τ&lt;e</td>
</tr>
<tr>
<td>already</td>
<td>¬e&gt;e</td>
<td>a∩≤t</td>
<td>e&lt;τ</td>
</tr>
<tr>
<td>yet</td>
<td>¬already</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anymore</td>
<td>¬still</td>
<td></td>
<td></td>
</tr>
<tr>
<td>again</td>
<td>e¬e`e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>only(yet)</td>
<td>¬e`e¬e?</td>
<td></td>
<td>τ&lt;e</td>
</tr>
<tr>
<td>just</td>
<td>only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phasal verbs**

Phasal verbs are a lexical alternative to aspectual affixes and phasal adverbs. They come in many varieties with varying input and output conditions on event type. The aspectual verb *continue* (*keep, go on*) is basically a grammatical variant of *still* (so its denial *stop* is a variant of *no longer*). *It kept raining/still rained when we left* are very close, but a scope difference is felt between *It went on raining for days* *(rain∩days)* and *It still rained for days* *(rain∩days)*.

The aspectual verbs *begin/start* and *end/stop* pick out initial and final bounds of events. Thus *begin, continue, stop*, and *not begin* form another square of opposites (Löbner 1990:88). The verbs *repeat* and *resume* are variants of *again* for closed and open event types, respectively. Portuguese has aspectual verbs *tornar a* which equals *repeat* and *voltar a* which equals *resume*. Not unexpectedly, the former accepts closed events and the latter open ones.

In Slavic languages, phasal verbs of beginning, ending and continuing select imperfective stems (Lindstedt 1985:40). In Finnish, the partial object form is used with complements of *alkaa/lakata/jatkaa* ‘start/stop/continue’. Hungarian (quod vide) apparently allows result particles on complements of verbs of beginning and ending (Johanson 1998:9.5). This may serve as an index of grammaticalisation of a result adverb (Johanson 1998:§9.4). Compare English *The alligator started to gobble down/up its prey*, where *up* is an aspect marker. There is something peculiar about *start to write up your thesis*; as there is about starting to finish something as opposed to starting just to do it. *Stop using up your allowance or It keeps coming back* get iterative readings.

For *continue*, it is obvious why it should take open event types: closed events cannot be continued. I submit this is also why verbs of starting and stopping obey the same constraint. Starting and stopping form a paradigm with continuing: one continues doing what one has started doing unless one stops doing it. It is probably no coincidence that phasal verbs in English take *ing* complements.

Different verbs of starting and stopping are sensitive to lexical aspect.

<table>
<thead>
<tr>
<th>verb</th>
<th>just</th>
</tr>
</thead>
<tbody>
<tr>
<td>start</td>
<td>¬a.a</td>
</tr>
<tr>
<td>stop</td>
<td>a¬a</td>
</tr>
<tr>
<td>set about</td>
<td>m/m</td>
</tr>
<tr>
<td>finish</td>
<td>m\m</td>
</tr>
<tr>
<td>take up</td>
<td>¬a+a²</td>
</tr>
<tr>
<td>quit</td>
<td>a²¬a</td>
</tr>
</tbody>
</table>

**Table 14**

*begin/start* pattern with the progressive. They are awkward with states unless they are turned into processes: *We started owning the house, She began to remember the date*. (Freed 1979:83). In French *Jean commence a avoir une maison/cinq voitures* ‘Jean is beginning to have a house/five cars’ sound odd, but *Les ouvriers commencent a avoir maisons* ‘Workers are beginning to own houses’ or *Jean commence a avoir beaucoup de voitures* ‘Jean is beginning to have a lot of cars’ are good (Lamiroy 1987).

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93 Indo-Iranian languages form perfectives using a limited number of closed support verbs with meanings *come, go (out), stay, stop, sit, put(in, on), give, take (out), leave, throw*. Hook 1991.
The phasal verbs set about/finish specialise for accomplishments.\textsuperscript{94} The verb finish picks out a final accomplishment, including the result state, so finish building a house implies finishing the house while stop building a house doesn’t (Dowty 1979:182-183). Finishing itself is an accomplishment so He was finishing building the house does not imply He finished building the house and He didn’t finish building the house implies He stopped building the house (Bennett/Partee 1972). Take up/quit specialise for continued activities. The distinction between stop and quit is that stopping can be temporary, quitting is for good, i.e. it means begin to keep not Ving.\textsuperscript{95} End picks up the end of a closed event.

Verbs for continuing make small but significant differences too:

\begin{align*}
\text{continue} & : a^+a \\
\text{resume} & : a^-a^+ \\
\text{keep} & : aa \\
\text{repeat} & : b^+b^+
\end{align*}

Table 15
Still and keep differ in focus: keep Ving denotes aa and still V denotes a^-a. It kept raining when we left (leave\(\cap\)rain).rain and It still rained when we left rain.(leave\(\cap\)rain). are very close, but not quite the same: What examples like this show is that behind global impressions, small but significant differences can be found on the concrete level of conditions of truth and denotation.

Huddleston (1967:797) notes phasal verbs do not allow a separate time adverbial on the main verb:

\begin{quote}
At 5 o'clock he began to wake up at noon.
\end{quote}

This is due to the fact that the phasal verb begin requires an open complement, which die at noon is not. Last summer he began to wake up at noon is fine with a habitual complement.

Common cross-linguistic idioms for continuation are e along, e away, e and e, and go and e. By my definitions continue e is e\(\cap\)e which entails contiguity. No surprise that go should be used to express continuity, for continuity is the specific property of motion as a change of place. Formally, density and continuity make go equal go.go. By definition, then, it is just continuity of go which makes it entail continue go. By the same token go entails go on, go by, and away (see section on paths). Combining these results, we can actually show that all of the above idioms for continuation boil down to iteration.

The aspect type of phasal verbs themselves can be read off of their definitions. Starting and stopping are (comparative) changes, continuing is a continuation.

Compare also the equivalence of en stop and go or open and close to fi pysähdellä ‘stop repeatedly’ or availla ‘open repeatedly’. It is not difficult to show that these event types are iteration equivalent:

\begin{align*}
\text{(stop . go)} & = \text{(go . } \sim \text{go . go)} \\
\text{stop}^\ast & = \text{(go . } \sim \text{go)}^\ast
\end{align*}

The equivalence of these event types is a special case of a more general formal theme of rewriting regular expressions (Antimirov/Mosses 1994, Calvanese et al. 19??). See appendix on formalism.

Aspect and negation
Typologically, negation is said to associate with open event type, or imperfective aspect (Lindstedt 1985:204). In Finnish, the partitive object occurs in negative and imperfective contexts (with an ambiguity). In Russian, the imperfective is used to negate an event “entirely”, while the negation of a perfective may only negates its completion. In Bulgarian, negative imperative is only formed from the imperfective stem (Scatton 1984:§6.2231). Many languages can make fewer aspect distinctions in negative clauses than in positive ones - including Finnish (Dixon 1995).

\textsuperscript{94} set about and finish seem to translate to Portuguese pôr-se a and acabar de The latter is also used as a near past sense not restricted to accomplishments.

\textsuperscript{95}Stop/quit correspond to parar/deixar in Portuguese. Give up (quit) and cease (stop) are further near synonyms.

Arthur is een week lang *(niet) over die tak gestruikeld
'Arthur has *(not) stumbled over that branch for a week'.

A duration adverb like *een week lang 'for a week' is odd for a (singular) closed event *struikelen 'stumble', but fine when the event is negated. This suggests that *een week lang scopes over *niet *struikelen, 'not stumble', negation turning the closed event type into an open one (Chétrit 1976, Link 1998:255). The idea in itself is not far considering that closed is defined as the complement of open.

Dowty's claim has been contested (Asher 1993, Le Draoulec 1994). Heinämäki (1974:15) finds problems with an assumption that negative clauses in English at large are durative (i.e. open, 1974:181):

We were worried while John did not come/was away.
We got worried when John did not come/was away.

She finds a negated change in a *while sentence odd (compare did not come to the positive state was away, which is ok). With when, in contrast, did not come is fine, implying some appointed time or deadline (John did not come at the appointed time/in time). Here, was away is odd unless it too refers to some closed event related to John's absence (e.g. the time of our finding it out). Here the negation of a change appears closed (a bounded absence of change). A minimal pair where *while seems to require an open aspect (Asher 1993, Le Draoulec 1998):

When Mary did not eat the cake, John washed the dishes.
While Mary was not eating/would not eat the cake, John washed the dishes.

Further evidence comes from durative adverbials. Bare object like adverbials of duration are odd with negation in English, *for is required.

John did not show up a long time
John did not show up for a long time.

Not until does not seem interchangeable with until not in English:

John did not come until 3.
It was not until 3 that John came.
It was until 3 that John did not come/was away.

Instead of *while not one prefers before/until:

What did we eat while/as long as margarine was not invented?
What did we eat before/until margarine was invented?

This data suggests that negation does not turn closed events into open ones, but rather scopes over adverbials. But then what about English *for in negative context? Vlach (1993:263) in fact claims that *for is a polarity item (like any), interchangeable with in in a negative polarity context like

This is the first/only proper meal I have had for/in a week. (Mittwoch 1988:222)

The point of Mittwoch's example is that a narrow scope existential any/for within a unique quantifier first and only implies existence which a wide scope universal any/for cannot do. In the context of Vlach's example, for thus has to stay in the scope of the negation which means it must be a narrow scope existential. Vlach notes that similar observations apply to during and until.

Interestingly, Finnish has a separate negative polarity form in the illative case for this context, distinct from both the in and for cases, allowing to express the entire Square of Oppositions with different cases:

Lihoin viikon. 'I gained weight for (acc) a week.' *(all)
En lihonut viikoekaan. 'I did not gain weight even for (ptv) a week.' *(not all)
Lihoin viikossa 'I gained weight in (iness) a week' *(some)
En lihonut viikkoon. 'I did not gain weight for (illat) a week'. *(no)

Even Verkuyl's observation is not a counterexample, if Dutch over die tak struikelen is unmarked for iteration 'stumble (at all, even once) over the branch', for iteration creates an open event type.
Quantifying over the denial of a truly singular count event produces slightly curious results.

The operation was a success: the patient did not die for a week.

As expected, a change of subject to a nonsingular one saves the sentence:

The operation was a success: no patient died for a week.

The upshot of the findings in this section is that Dowty's claim does not generalise to all event types. It holds for open events whose contrary is open (Asher 1993:53). What does generalise is that the aspect type of a negative phrase can be computed from the logical interaction between aspect and negation.

Negation does not require nor automatically create open aspect, but often an open event type is what one is out to deny (Hedin 1998). The denial of any occurrence of an event type at all is at once an open aspect type and the strong denial (contrary or pointwise complement) of one.

A closed denial of a closed event type has a function as well. It denies the assertion but leaves the presupposition in place. The presupposition is that an occasion for the event type is present (its prerequisites are there at the occasion), the assertion denied is that the event reaches closure then. Though the assertion fails, the implication of a definite occasion remains, and thus the event type of the denial remains a closed one. More on this in the section on absence of change.

Heinämäki (1974:184) notes that negation is odd in before/after clauses:

We waited inside before it did not rain. (Cf. until it did not rain/before it stopped raining).
Bats stop flying after it is not dark. (Cf. after it gets light/as soon as it is not dark).

Considerations in the section on order showed that after is peculiarly vague with open event types: it rains after it blows can mean either it rains when it blows or it rains when it does not blow. Either way, after does no real work here, it can always be replaced by when. A fortiori, negative after it is not dark is vague about what time is intended, day or night.

Before is a negative polarity item, so before it did not rain involves a double negation, replaceable by a positive when it rained.

Hamann (1989:73) makes the same observation about

Eva left before/after/when John did not come.

The problems remain when the sentence is rephrased positively (stayed away), so it is not just the negation that causes the problem. The sentences are not all equally bad. Before seems odd; after is better, when is fine (recall that when is closed). In the section on temporal connectives, it is found that the before/after subevent must be closed toward the main event. Not come is open toward the past. There is no inherent first point of stay away. If an expected time of arrival can be provided, the sentence is saved. For before, it remains hard to see how Eva could foresee John's future absence. The timing must be ascribed to the narrator, not Eva.

Eva left before/after/when John did not come at two/in two hours.

Ergo: negations are odd because (when) they do not denote bounded events. These suggestions are confirmed by the better results obtained when the negation has an obvious bounded positive paraphrase:

We had better stop before we don’t see anything (i.e. it is too dark to see anything).

In general, Hamann (1989:74) notes that negated sentences can occur with before or after if a closed reference time is supplied from outside.

After John didn’t come to the party, Eva got really angry.

Eva was quite happy before John didn’t phone her on her birthday/any more.

As Hamann (1989:74) observes, half closed until and closed when are also ok here:

Eva chased John away until he did not come back.
Eva left when John did not pay attention to her.

¬care\when\leave

There need not be any particular event which triggered the departure, she just got fed up. When does not mean after here: there is no implication that John stopped misbehaving. This fits the observation that anterior perfect is not felicitous in French in this constellation (Le Draoulec 1994:258):

Quand John ne fut pas venu, Eva s'inquieta. 'After John had not come, Eva got worried.'

Chétrit (1976) and Le Draoulec (1994) make similar observations about French. Un jour is indispensable in

Nous avions l'habitude de nous retrouver à cet endroit. Puis en jour il ne vint pas au rendez-vous. 'We had the habit of meeting in this place. Then one day he did not come to meet me.'

Alternatively, open pas 'at all' must be changed to half closed plus 'any longer'. French seems to grammaticalise the aspect distinction in ne pas/plus to the degree that only the former is allowed below (Le Draoulec 1994:260):

Depuis qu'elle n'est plus amoureuse, elle est heureuse. 'After she is not/no longer in love, she is happy'.

love.¬love < happy.

J'attendrai jusqu'à ce qu'il ne soit plus énervé. 'I'll wait until he is no longer nervous.'

now<wait.(nervous`¬nervous)

Heinämäki (1974:184) suggests negation is not allowed in since clauses. Again, counterexamples exist when the negation translates to a positive event: Eva has been unhappy ever since John has not talked to her. (= has refused to talk to her)

Young has a final bound and old has an initial bound but not vice versa (death does not make you younger). Given the vagaries of after and before with open events, it is much preferred to use when.

It is best to marry before you are old/young. After you are young/old it is too late. (Rather: when/once you are old, after you get old)

Theories of aspect

The simplest theories of aspect are taxonomies. The usefulness of aspect classification in the first place has been questioned by Verkuyl (1993). It is probable that aspect classes, like many other taxonomies in science, are epiphenomena of more complex relational theories of event structure. But it is also true that taxonomies have a practical interest, if only as theorems from more fundamental axioms.


Aspect classes can be characterised syntactically by grammatical constraints (Vlach 1993) or structural representations, deductively by characteristic inferences or postulates (Vendler 1957), or semantically by constraints on valuations (Dowty 1979), with obvious connections between the different criteria.

Grammar tests

Aspect classes are based on more or less reliable and language specific grammatical tests (Lapolla/Van Valin 1997:§3.2.1).

In recent EU project work on cross-linguistic semantics, so-called top ontologies are developed which are essentially polyhierarchic featurisations of major cross-linguistics semantic distinctions. Characteristically, such ontologies are better developed for nouns than for verbs.

Two such ontologies, the Simple/Parole cross linguistic semantics lexicon project on the one hand, and that of the EuroWordNet project on the other hand, diverge already in the number of basic aspect distinctions: the former has a top level dichotomy between states and events, the latter a trichotomy between states, events, and processes. Perhaps the best known typology aspect of Vendler (1967) proposes a fourfield.
Those theories which make a two-way split at the top all set off states from (other) events. There is a received list of tests for stativity (Lakoff 1965, Gruber 1976, Miller and Johnson-Laird 1976:472-9, Langacker 1987, Dowty 1979, Smith 1983, Frawley 1992), which includes the following:

- no progressive
- no happen or do anaphora
- no imperative
- no manner adverbials (carefully, deliberately)

My claim here is that these tests do not create one dichotomy but draw several roughly related ones:

No progressive: In my definition, simple states are filters, i.e. upward closed under join and downward closed under subevents. In other words, given that in x of e denotes the event type of arbitrary parts of an event e,

\[ s = \text{in } x \text{ of } s \]

If progressive is defined as a partitive operator in x of e, will be vacuous when applied to simple states. Frawley (1992:149), inter alios, considers vacuity sufficient to explain why progressive does not apply to states. A problem with this line of explanation is that vacuous rule applications are not always ungrammatical. My definition for the English progressive here specifies x further to a process p, which makes the English progressive not just vacuous, but inapplicable to simple states. This lets the English progressive apply to impure states which imply a process (is standing, is being noisy, is knowing more and more), and the Portuguese temporary state progressive to apply to temporary states (estou a ver/compreender).

No happen or do anaphora: Happen and do are verbs with little content beyond aspect and diathesis. But they do have specific aspect and diathesis, and this is why they can be used to sort out other events. Happen is dynamic (a non-state); it entails one or more changes. What happened? is correctly answered by nothing if and only if nothing (significant) has changed. Do is an agentive auxiliary corresponding to agentive operator do below. Do entails happen. What happened was I caught a cold, what I did was I caught myself a cold.

No imperative: The imperative grammaticalises requests or commands. Requests and commands are moves addressed to players in a language game, and make literal sense only if the move can influence the strategy of the player being addressed. Therefore, the connection between imperative and event type is indirect, mediated by relevance (inference concerning rational play). In particular, there is no automatic ban on imperatives of states. Some states are hard to bring about, prevent, or maintain, others aren’t: Believe me, be my guest, don’t be an idiot, sleep well, stay here. Besides, not all imperatives make requests or commands, some are permissions, concessions, or threats: Have it your way, leave us and be damned.

No manner adverbials: Manner adverbials (roughly, adverbials answering the question how) are a motley crew. How in general asks for a proper specification of an event type. Manner adverbials that help singling out states include those which specify a process, e.g. slowly, gradually. Adverbs often quoted in this context include intentional adverbs like carefully and deliberately. These entail a plan by an animate subject: He was there deliberately. Again there is no wholesale criterion here, the entailments have to be worked out case by case.

Gabbay and Moravcsik (1980:63) say states (i) have duration (are not instantaneous), (ii) imply no change, (iii) are connected (have no gaps). Property (i) follows from openness, (ii) from homogeneity. (iii) is ambiguously stated. It does follow from homogeneity that a state has no gaps, i.e. it is not true at a connected time unless it is true for that time. This does not prevent a state from being disconnected, i.e. true at separate connected times. This distinguishes states from heterogeneous processes like work which can be true of a longer stretch without being true of all shorter ones. Compare Swiss cheese. Swiss cheese contains holes, but the holes are not cheese.

Vlach (1993) lists five tests for (English) statives.

1. No progressive: Max is being in the kitchen, having a car.
2. No manner adverbials: Max is carefully under the table.
3. No do anaphora: What Betsy did was owe Max dinner.
4. Simple present nongeneric: Max is here (right now).
5. No narrative progression: Max was here when Mary arrived.

The first two tests diagnose simple event types (states and achievements). The progressive is excluded because (insofar as) there is no associated process to be in. The relevant manner adverbials (carefully, slowly) diagnose complex, often agentive events (activities and accomplishments). Their absence also
characterises achievements. Do tests for agentivity. Agentive events are complex (they involve cause and effect). The simple present test is specific for generic simple present. Only states are open and nonextended which means that they can match events of arbitrary size. The last test would work better by inverting it: a stative when event Mary arrived when Max was here overlaps a closed main event. The converse may not be true (Max was happy when Mary arrived).

**Features**

Criterial taxonomies group aspects by cross-classifying features into a table or matrix or by hierarchical features into a tree (or any combination of these). The following cross-classifying feature matrix for Vendler’s fourfield can be taken as a starting point.

<table>
<thead>
<tr>
<th>closed (count)</th>
<th>open (noncount)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>simple</strong></td>
<td></td>
</tr>
<tr>
<td>achievement</td>
<td>state</td>
</tr>
<tr>
<td><strong>complex (extended)</strong></td>
<td></td>
</tr>
<tr>
<td>accomplishment</td>
<td>activity</td>
</tr>
</tbody>
</table>

**Table 16**

Simple aspect types have no internal structure (take no progressive), complex ones have (and do). Simple event types have no minimum extension in time, while the complex ones do. Noncount aspect types are open, take measure adverbials and obey Aristotle’s principle, count ones are closed and don’t. Most count event types are resultative, most noncount ones are irresultative.

There are numerous aspect featureisations in the literature. Friedrich (1974) derives the major aspectual distinctions from a combination of three abstract features: durative/nondurative, completive/noncompletive, and stative/nonstative, encoding the oppositions point versus extension, termination versus continuation, and act versus state.

Dowty (1976:184) classifies aspects in terms of four binary features [change], [momentariness], [agency], and [complexity]. Carlson (1981) proposes three features [point], [extended], and [continuous], Brinton (1988) proposes features [telic] for resultatives and [multiplicity] for iteratives. Raible (1990) tabulates feature distinctions in aspect literature related to Vendler’s taxonomy as follows.

**Table 17**

Verkuyl (1993:19) intersects two features [ADD TO] (incremental) and [SQA] (specified quantity) to arrive at a three-way ontology of states, processes, and events. States involve neither process nor bounds, terminative events involve a bounded process. The taxonomy is treelike in that the SQA feature is only applicable to incremental event types. Verkuyl contends Vendler's distinction between achievements and accomplishments (whether the event has to take time or not) as an ontological (lexical) rather than a structural (grammatical) distinction.
Frawley (1992:327) criticises cross-classifying feature approaches for arbitrariness and inability to predict typological markedness preferences among aspect distinctions. A tree is a more constrained representation than the matrix in that it only represents some of the cells in the matrix. There is no node for the classes of simple and complex event types in the following tree representation of Vendler’s fourfield. If we invert the hierarchy, there are no nodes for open and closed event types. Many writers fit features into trees by constraining the combinatorics of features. Mourelatos (1981) makes Vendlerian distinctions with a specific topology and nomenclature: The terms in parentheses are reserved for agentive events.

Gabbay and Moravcsik (1980:65) have yet a different tree. According to it, a state holds for some duration without interruptions and implies no change in the subject. Events have no duration, imply change, or allow gaps. Processes (write a book) are made up of a series of changes which culminate in a state not reached while the process takes place. Mere events (e.g. walk) do not culminate. Both durative classes allow gaps. Events of no duration (hit, knock) can be repetitious or non-repetitious.
Gabbay’s and Moravcsik’s description of a state is consistent with ours. Their events are the complement of the class of states. Gabbay and Moravcsik’s mere events are Vendler’s activities and my processes, their processes are Vendler’s and my accomplishments, their repetitious events are my series, and their nonrepetitious events my achievements or cycles. (This goes to show that descriptive names don’t count for much in this game.) Gabbay and Moravcsik (1980:70) also have an alternative classification:

In this tree, a series hangs under feature count, which implies that Gabbay and Moravcsik’s count distinction here is the count/mass (discrete/continuous) distinction, not the count/noncount (closed/open) distinction.

Here is another tree from Bach (1986): This tree depends on features complex, pointwise, open and resultative. States are open and pointwise. Static states (be drunk, own) are atomic, dynamic states (sit, stand) composite. Processes (walk, push) are complex and open, events are closed. Events are protracted (complex) or momentaneous (simple). Culminations (die, reach) are resultative, happenings (notice, flash) are not.

Langacker (1982, 1987) couples the distinction between simple/complex event types (mass/count, continuous/discrete) with the distinction between noncount/count (unbounded/bounded, open/closed), to get a two-way diagonal contrast between perfective processes (accomplishments) and imperfective processes (states). His perfective processes involve change through time and imperfective processes do not (1987:254). His perfectives allow the progressive in English, while imperfectives do not. (1987:256). Examples of Langacker’s imperfective processes are have, hate, know, resemble, cost, contain, occupy, want, which are states. For Langacker, walk is perfective (cf. Smith 1991). Langacker (1987:254fn) notes his perfective/imperfective terminology is other people’s active/stative distinction. I prefer to keep all the traditional pairings perfective/imperfective, static/dynamic and active/passive separate and stick to their traditional meanings. The first one flags the closed/open distinction, the second one the state/change distinction, the third one diathesis (causation and agency).

Langacker (1982;272) further distinguishes between (timeless) states and imperfective processes. Imperfective processes are temporally extended states, conversely, a state is the pointwise limiting case or cross section of an imperfective process. (An imperfective process is in turn a degenerate case of a perfective process where the change is nil.)

Quirk et al. 1985 have the following classification (Matthews 1987). My own counterparts are anticipated on the right side.

<table>
<thead>
<tr>
<th>Quirk name</th>
<th>Example</th>
<th>Carlson MS</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>static</td>
<td>quality</td>
<td>he is tall</td>
<td>permanent state s</td>
</tr>
<tr>
<td></td>
<td>state</td>
<td>he is angry</td>
<td>temporary state gen prog pf s</td>
</tr>
<tr>
<td></td>
<td>stance</td>
<td>he sits</td>
<td>dynamic state a cause s</td>
</tr>
<tr>
<td>dynamic</td>
<td>going-on</td>
<td>it rains</td>
<td>process a</td>
</tr>
<tr>
<td></td>
<td>agentive</td>
<td>he talks</td>
<td>activity e do a</td>
</tr>
<tr>
<td></td>
<td>conclusive</td>
<td>it ripens</td>
<td>relative change afle</td>
</tr>
<tr>
<td></td>
<td>nonagentive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
agentive agentive he drinks it accomplishment a do c
punctual nonconclusive nonagentive momentary event he sneezes cycle pf s
agentive momentary act He fires a gun agentic cycle c do pf s
conclusive nonagentive transitional event He arrives change c
agentive transitional act He sits down agentic change e do c

Table 19

Axioms


Galton’s logic of aspect

Galton’s (1984) logic of aspect is an axiomatic treatment of aspect in a Priorian framework. As Galton (1984:37) points out, Priorian syntax has no single representation of the event ‘p and then q’: It (has) started raining $\neg p \land p \lor P(\neg p \land p)$ and It will start raining $\neg p \land Fp \lor F(\neg p \land Fp)$ have no common subformula corresponding to start raining. (Intuitively, this is because Priorean tenses are indexical tenses and not aspects: they have a particular point of reference built in from the start.) Galton proceeds to correct this deficiency by supplementing Priorian tense logic with aspect operators which form events (event radicals) E out of states (propositions) p and back. He does not provide a direct semantics for events or aspect operators in 1984.

Galton (1984) agrees with Hamblin (1971) that propositions are true or false at times, while events occur in intervals. Yet technically, Galton’s (1984) system remains an application of Priorian tense logic. Event radicals and aspect operators are only contextually defined, ‘syntactic sugar’. The virtual (term rewriting) treatment of events allows Galton (1984) to stick to Priorian tense logic where only propositions are true or false of (moments) of time.

The definitions are as follows (one possible translation to my notation given on the right):

$$\begin{align*}
Perf \text{ Ingr } p & \quad P*(P\neg p Ap) \quad \neg p \land p \leq \text{now} \\
Pros \text{ Ingr } p & \quad F*(\neg p Af p) \quad \text{now} \leq \neg p \land p \\
Perf \text{ Po } p & \quad P*(P\neg p Ap \land p) \quad \neg p \land p \leq \text{now} \\
Pros \text{ Po } p & \quad F*(\neg p Af (p \land p)) \quad \text{now} \leq \neg p \land p \\
Prog \text{ Po } p & \quad P\neg p Ap Af \neg p \quad \neg p \land p \land p \neg \text{now}<
\end{align*}$$

Table 20

Here Ingr (ingressive aspect) and Po (‘pofective’ aspect ) separate the two readings of my perfective. They take propositions p to event radicals E represented by the subformulas Po p and Ingr p. Event radicals are not true or false of times directly. They are related to times through the mediation of one of the phasal aspects Perf (nonfuture), Pros (nonpast), or Prog (closed progressive) which take event radicals back to propositions. The closed progressive says that if an event is under way then it has not always been under way, and will not always be under way in the future (Galton 1984:94). Although this much is often implicated by the progressive, I feel it is too much to make it an entailment. What Dalton calls open progressive is a forward branching modal closed progressive M Prog E based on the same idea as Dowty (1979) (see also below).
Through the equivalences, aspects reduce to Priorian tense logical relations among propositions. The translations on the right allow mapping Dalton’s logic of aspect to the present framework and exploiting his results.

**Valuations**

Dowty (1979:165) following Vendler 1957 and Taylor 1977 suggests the following constraints on valuations for defining aspect classes:

- A *stative* predicate is true at an interval I iff it is true of all moments in I.
- An *activity* or *accomplishment* is only true of extended intervals.
- An *achievement* or *accomplishment* is false of subintervals.
- An *activity* is true of extended subintervals.

These postulates are close to mine. My simple states satisfy a downward closure condition entailing Taylor’s. Activities and accomplishments satisfy Taylor’s extendedness condition because they have internal structure. Taylor’s postulate for achievements and accomplishments is stronger than my condition on closed event types which rules out concatenation but allows nesting. Taylor’s closure condition on activities (cf. also Link 1998) goes in the opposite direction. My condition on open event types is the converse upward closure condition from Quine 1960 (cf. Carlson 1981, Krifka 1990, 1998). Carlson (1981) and Verkuyl (1993) conclude that only upward closure plays a role in aspect composition. For another axiomatics and its critique cf. ter Meulen (1983) and Verkuyl (1993).96

**Two-level theories**


Smith’s (1991:6,28) basic situation types are states, activities, accomplishments, achievements, and *semelfactives*, which are dynamic, atelic, instantaneous events (*tap, knock*), i.e. my cycles. These types are distinguished by three semantic features *static, durative, and telic*. Essentially the same system in feature tree format is found in Ehrich/Vater (1989:117).

<table>
<thead>
<tr>
<th>Situation type</th>
<th>Static</th>
<th>Durative</th>
<th>Telic</th>
</tr>
</thead>
<tbody>
<tr>
<td>state</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>activity</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>accomplishment</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>achievement</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>semelfactive</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 21

Smith’s (1991) calls her theory of aspect a two-component theory because basic situation types (lexical aspect) are distinguished from viewpoint aspect (grammatical aspect) and treated separately. The main types of viewpoint aspect are perfective, imperfective, and neutral viewpoint (1991:6). Smith (1991:§4.2.3) argues the neutral viewpoint is a separate aspect. I would rather say it is just the absence of (grammatical) aspect, i.e. lexical event type showing through. Smith’s argument for neutral viewpoint is that it makes a particular, unpredictable selection among possible viewpoint interpretations. In particular, neutral viewpoint leaves open event types vague between inceptive and imperfective readings, but excludes imperfective readings of closed event types. In my view, this asymmetry is predictable: open event types by definition have initial and medial occurrences, closed event types don’t.

The two-component theory is designed to allow for a form to instantiate a lexical situation type and a viewpoint at once. For instance, *Mary was walking to school* exhibits closed situation type but open

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96 Preservation of properties in Chu spaces (van Benthem 2002) might be applied to aspectual closure conditions Are natural language aspects preserved in scale and granularity changes for instance?
viewpoint. The cash value of the notion of visibility of a part of an event through a viewpoint aspect is that “only what is visible is asserted” (Smith 1991:99).

In my approach, this much is already achieved by representing the sentence as the composition \textit{prog pf walk} of lexical and grammatical aspect. This aspect type \textit{denotes} (asserts) an open event but \textit{entails} (modulo imperfective paradox) a closed one around it. There is no need to treat lexical and grammatical aspect as qualitatively different for that. Their difference is rather in degree of grammaticalisation (morphological exponency and scope).

Johanson (1998) classifies lexical aspect (internal phase structure) into five classes using four binary features. Feature [±t] is my feature (half)closed/open, [±mom] and [±dyn] are both covered by my \textit{simple/complex}.

| momentaneous finitransformative | [±tf, ±mom] | simple change |
| non-momentaneous finitransformative | [± tf -mom] | accomplishment |
| initiotransformative | [± ti] | acquisition |
| dynamic nontransformative | [±t, ±dyn] | process |
| non-dynamic nontransformative | [±t, -dyn] | state |

**Table 22**

Viewpoint aspect is classified by three binary features [±INTRA(terminal)], [±POST(terminal)], [±AD(terminal)] plus a finite tense distinction [±PAST]. An additional feature [±T] indicates presence/absence of an explicit marking of half-closure. The intended contrasts are exemplified by

| +INTRA | English \textit{was writing} | \textit{prog e} -INTRA | English \textit{wrote} e |
| +POST | English \textit{has written} | \textit{perf e} -POST | English \textit{wrote} e |
| +AD | Russian \textit{prochital} | \textit{pf e} -AD | Russian \textit{chityval} \textit{ipf e} |
| +PAST | English \textit{wrote} | \textit{pret} -PAST | English \textit{writes} pres |

**Table 23**

A mapping to the terms of the present formalism is indicated in the table. As the mapping indicates, Johanson's features code aspect operators (regular expressions) rather than classify denotations (regular languages).

Johanson’s system divides perfective into half-closed [+AD] and closed [-INTRA] types and imperfective correspondingly between unmarked [-AD] and marked [+INTRA] cases. [-INTRA] covers both perfective and simple aspects [-INTRA]*. [+INTRA] (marked progressive) and [+AD] (marked perfective) do not appear in the same system (for instance, English only has the former and Russian the latter).

Johanson (1998) arranges finer distinctions among imperfectives and perfects (§8.5-6) on a scale of focality from high through low to no focality:

<table>
<thead>
<tr>
<th>perfect</th>
<th>resultative</th>
<th>anterior</th>
<th>existential</th>
<th>simple past</th>
</tr>
</thead>
<tbody>
<tr>
<td>imperfective</td>
<td>progressive</td>
<td>imperfective</td>
<td>habitual</td>
<td>modal</td>
</tr>
<tr>
<td>in p of e</td>
<td>\textit{ipf e}</td>
<td></td>
<td></td>
<td>\textit{σ Q (q R a)}</td>
</tr>
</tbody>
</table>

**Table 24**

The insistence that aspect and Aktionsart are different levels leaves Johanson with only vague terms (affinity, fertility) to explain similarities and interdependences across the boundary, instead of just saying (as I do) that precisely the same distinctions get expressed now this way, then that.
**Grammatical aspect taxonomies**

Comrie (1976:25) proposes the following aspect hierarchy based on typological markedness comparisons. Perfective/imperfective is more commonly grammaticalised than habitual/continuous.

![Aspect Diagram]

which is more frequent than progressive (Frawley 1992:326).

Bybee et al (1994:127,139) following Comrie (1976) distinguish besides progressive, continuous, and habitual also iterative $b^*$ frequentative $pf^*$ $e$, and continuative $aa^*$ uses of imperfective. By their definitions, progressive views action as ongoing at reference time. Continuous views a situation, dynamic or stative, as ongoing at reference time. Habituals describe situations characteristic of an extended period of time. Iterative describes repetition of an event on a particular occasion. Frequentative indicates repetition of occasions. Continuative is the event type of permanence, or ‘keep on doing’. Others (Bache 1982) call such subdivisions Aktionsarten. In my approach, such classifications are special cases of the event type definitions of the corresponding aspect operators. It is not difficult to derive the above tree and the associated characterisations from the definitions of the formulas. 'Nonprogressive' is an open event in simple aspect.

**Phase**

By Comrie's (1976) definitions, perfect is not an aspect (Johanson 1998:§8.2). The name of phase or phasal aspect was given to the English perfect in Trager and Smith (19??) and taken up by Joos (1967). The phasal point of view is also pursued in Freed (1979), Talmy (1985), Moens (1987), van Voorst (1988), and Brinton (1988). Raible (1990:208) presents a classification of phasal aspects with reference to the time line. These are precisely the topological tenses consistent with the constraints of quality and bounded (or topological) continuity in van Benthem (1985,1986).

<table>
<thead>
<tr>
<th>pre-initial phase</th>
<th>initial phase</th>
<th>middle phase</th>
<th>terminal phase</th>
<th>post-terminal phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>cantare habeo</td>
<td>cantare incipio</td>
<td>canto</td>
<td>cantare destino</td>
<td>habeo cantatum</td>
</tr>
<tr>
<td>near future</td>
<td>inception</td>
<td>activity</td>
<td>achievement</td>
<td>near perfect</td>
</tr>
<tr>
<td>$e\cdot$</td>
<td>$\sim e\cdot$</td>
<td>$\sim e\cdot$</td>
<td>$e\cdot$</td>
<td>$e\cdot$</td>
</tr>
<tr>
<td>acquisition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sim ee$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>accomplishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e\cdot$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sim ee\cdot$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 25**

An instructive layout also presented in Raible (1990:210) is the following:
Raible notes that the layers of distinctions in his table interlock in ways that prevent the deduction of the other layers from any one layer. However, it is easy to see how all the distinctions are related through equations in the event algebra.


<table>
<thead>
<tr>
<th>Name of the layer</th>
<th>Categories belonging to the layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of state</td>
<td>atelic ee⁺</td>
</tr>
<tr>
<td></td>
<td>telic ¬ee</td>
</tr>
<tr>
<td>Phase</td>
<td>intermediate</td>
</tr>
<tr>
<td></td>
<td>non-intermediate</td>
</tr>
<tr>
<td></td>
<td>e\le/e</td>
</tr>
<tr>
<td></td>
<td>(beginning) ¬e\le</td>
</tr>
<tr>
<td></td>
<td>(end) e!/e</td>
</tr>
<tr>
<td>Movement</td>
<td>static</td>
</tr>
<tr>
<td></td>
<td>d(t)=d(u)</td>
</tr>
<tr>
<td></td>
<td>dynamic</td>
</tr>
<tr>
<td></td>
<td>d(t)≈d(u)</td>
</tr>
<tr>
<td></td>
<td>augmentative</td>
</tr>
<tr>
<td></td>
<td>d(t)&lt;d(u)</td>
</tr>
<tr>
<td></td>
<td>diminutive</td>
</tr>
<tr>
<td></td>
<td>d(t)&gt;d(u)</td>
</tr>
<tr>
<td>Duration</td>
<td>durative ee</td>
</tr>
<tr>
<td></td>
<td>punctual ¬ee</td>
</tr>
<tr>
<td>Repetition</td>
<td>repeated (¬ee)²</td>
</tr>
<tr>
<td></td>
<td>unique ¬ee</td>
</tr>
</tbody>
</table>

Table 26

The upshot of the survey in this section is that many prima facie different classifications are just alternative partitionings of the algebra of events. In my view, the algebra is primary and neutral with respect to partitioning, as long as the classes are definable. Many different trees and featurisations can be erected on the calculus, more or less useful but equally correct. Langacker (1982:274, 1987:258) makes the same point. An even curiouser topological derivation of event type diagrams has been based on Thom’s theory of catastrophes (Thom 1970, Wildgen 1982).

**Typologies**

Frawley 1992 is an introductory text into linguistic semantics inspired by cross-linguistic typology and cognitive grammar. Though Frawley's analyses remain sketchy in many places, it has several suggestive points of contact with my line of thought. Frawley (1992) has a four-part event typology characterised in terms of both diathesis and aspect.\(^7\)

1. States: static events (*statives*)
2. Acts: events that are executed (*actives*)
3. Inchoatives: events that unfold (roughly Vendler’s achievements and Ryle’s achievements without an associated task)
4. Resultatives: events that come to an end (roughly Vendler’s accomplishments, Kenny’s performatives, and Ryle’s achievements)

Acts involve causation, inchoatives are not causative. Resultatives combine acts and changes of state. States and acts take *for* time adverbials but not *in* adverbials. Inchoatives accept *in* but not *for*. Resultatives take both *for* and *in*. States are true down to points, acts down to intervals. Inchoatives are

---

\(^7\)Frawley says his classes are not mutually exclusive, there are overlaps between them (Frawley 1992:183). Apparently at least some inchoatives pass some criteria for acts.
true between two states, resultatives at intervals. The typology seems to roughly agree with Vendler's fourfield.

Alongside event types Frawley discusses six major aspects: perfective/imperfective, telic/atelic, punctual/durative, semelfactive/iterative, progressive, habitual, and five minor ones: inceptive, terminative, prospective, retrospective, and intensive.

To arrive at a typology of aspect, Frawley (1992) combines tree and feature ideas by distinguishing three major aspect categories, open, closed, and phase. Within each major category, subcategories are ordered for markedness according to distributional criteria. The approach follows Chung and Timberlake (1985) and Brinton (1988:53), arguing that a model for aspect must be both compositional in order to generate aspect categories from a matrix of notional features, and hierarchical in order to account for secondary systems of aspectual marking.

OPEN: imperfective > durative/habitual > progressive > iterative
CLOSED: perfective > punctual/telic > semelfactive
PHASE: intensive/inceptive > prospective > terminative/retrospective

Frawley (1992:329) suggests that phase aspects fall between closed and open aspects, something like semiopen or semiclosed events, closed on one end and open on the other.

Cross-categorial geometrical features discrete/continuous, extended/nonextended and interior/exterior are called on to distinguish between open and closed, punctual and durative, and progressive and iterative aspects, respectively. Further cross-categorial associations are suggested between resultatives and goals, iteration and number, prospective/retrospective and proximal deixis.

Bache (1985, 1995) is an attempt at a theory of markedness of derived aspect meanings. It postulates an intentionally oversimplified universal tense-aspect-actionality grid which allows conflicting combinations of tense, aspect, and Aktionsart. Such conflicts are resolved by coercing the meaning of one or another of the three components to the nearest compatible value. Actionality is split stepwise into the following situation types:

<table>
<thead>
<tr>
<th>Bache 1995</th>
<th>Carlson 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ACTIONAL</td>
<td>complex</td>
</tr>
<tr>
<td>simple</td>
<td>punctual</td>
</tr>
<tr>
<td>durative</td>
<td>telic</td>
</tr>
<tr>
<td>atelic</td>
<td>directed</td>
</tr>
<tr>
<td>self-contained</td>
<td>complex</td>
</tr>
<tr>
<td></td>
<td>open</td>
</tr>
<tr>
<td>-ACTIONAL</td>
<td>simple open</td>
</tr>
</tbody>
</table>

Table 28

This tree does not map neatly onto my calculus. It separates iterations from the rest of the open event types and punctual events from the rest of the closed event types. It is motivated by its intended interplay with a two-way perfective-imperfective perspectival aspect opposition and a three-way past-present-future tense system.

Bache's theory consists of the three skeleton systems, an enumeration of cases of conflict, and rules for resolving the conflicts with respect to the options provided by the systems. Although individual conflicts are enumerated in the formal statement of the theory, the discussion shows that they ought to be derivable from the definitions of features. Here is an example of a conflict resolution rule:

complex $\downarrow$ perfective $\rightarrow$ complex $\approx$ punctual $>.$ telic $>.$ self-contained

The rule says that the perfective of an iteration is a conflict which is resolved by coercing the iteration into a cycle, accomplishment or process, in this order of preference.
Bache thus construes aspect as a selector which picks out from the set of meaning options for the argument those compatible with its own meaning. The options are generated by the system separately. An alternative is to consider an aspect a constructor which derives new event types out of old ones.

From my point of view, Bache’s list of conflicts is quite redundant, largely because the key open-closed aspect distinction is not represented.

Role and reference grammar (Lapolla/Van Valin 1997) assumes a four-way classification of basic event types, whose aspectual projection is the Vendler classification.

**Situations**: static, non-dynamic states of affairs which may involve the location of a participant (a book being on the table), the state or condition of a participant (Maria being tired), or an internal experience of a participant (Fred liking Alice). states [+static, -telic, -punctual]

**Events**: states of affairs which seem to happen instantly, e.g. balloons popping, a glass shattering, a building blowing up. achievements [-static, +telic, +punctual] INGR

**Processes**: states of affairs which involve change and take place over time, e.g. a change in location (a book falling to the floor), in state or condition (ice melting, water freezing, clothes drying), or in the internal experience of a participant (Tanisha learning Swahili). accomplishments [-static,+telic,-punctual] BECOME

**Actions**: dynamic states of affairs in which a participant does something, e.g. Chris singing, the ball rolling, the sun shining, a fire crackling, Yolanda swimming, the ground shaking, Tyrone drinking beer. activities [-static, -telic, -punctual] do

The characterisations apply first hand to intransitives. Situations obviously correspond to my states. Events look like changes. Processes sound like comparative changes. Actions might be reflexive causative processes. These assignments are supported by a *cause-become* decomposition where states are primitive, and events, processes, and actions constructed with abstract verbs INGR, BECOME, and two-place do, respectively. INGR produces abrupt changes, BECOME gradual ones. Abstract verb CAUSE forms transitives from all event types.

The redundancy of three features against four classes reveals a hierarchy. Feature [static] only sets off states from the rest. Two features remain for three classes. The empty cell is at [-static, -telic, -punctual], which (if present) would split the Vendlerian class of achievements into telic changes and atelic cycles.

**Event calculi**

This section surveys other event calculi and compares them to the present one. An event calculus (algebra, logic) is a formal language for defining and combining event types. There is a host of different logics of events and actions studied in various fields. Kleene (1956, written in 1951) developed regular expressions specifically to describe events, and the event vocabulary persists in literature (Conway 1971) until the theory got subsumed under the theory of formal languages.

Von Wright’s (1963,1968) logic of change is one of the logical precursors. More recently, event logics has been developed in computer science, e.g. dynamic and process logics (Pratt 1979, Segerberg 19??, Harel et al. 1980, Harel 1984) Linguistic event calculi include Nowakovska (1973), Dahl (1974) and Desclés (1989). Dowty (1979) shares many features with the present one. Others are the algebra of events of Bach (1982) and the mereological calculi of Link (1983) and Krifka (1987,1989,1990).

To compare two formal languages to one another, one can look for a translation relation, a structure preserving mapping or morphism between the languages which translates the formulas of one to formulas of the other. I shall study such translatability relations between different calculi in order to see to what extent they agree in what they say about events.

von Wright’s logic of change consists of a two place operator $pTq$ read ‘$p$ and next $q$’ that forms changes out of states $p$ and $q$. The $T$ operator is interdefinable with my concatenation operator but not identical to it. Dowty (1979:144 ) suggests the following definition for $T$ in terms of intervals:

---

98. Wright (1963) extends the logic of change to a logic of action with operators $d$ for doing and $f$ for forbearing; e.g. $d(l¬pTp)$ reads ‘$p$ is done’.

\( pTq \) is true at an interval I iff \( p \) is true and \( q \) false at J, \( p \) is false and \( q \) is true at K, the lower bound of I is in J, the upper bound of I is in J, and no subinterval of I satisfies the same conditions.

This differs from my definition of \( pq \) in that concatenation implies nothing about the falsity of \( p \) and \( q \). All it says is \( p \) and \( q \) meet at a boundary; they (i.e. other tokens of the same event type) may go on and overlap. An open event type \( pfq \) can contain any number of overlapping instances of \( pq \) if \( p \) and \( q \) are compatible. Dowty’s definition of \( T \) could be approximated by \( p \neg p \neg q \) in my calculus. This coincides with \( pq \) when \( p \) and \( q \) are closed (for instance, event tokens). Heger (1967, see Raible 1990) uses a similar notation to describe aspects. Cf. also Schopf (1984), Löbner (1988), Sil’nickij (1988), Klein (1994).

Dowty 1979:74ff defines aspect classes in terms of formulas of an aspect calculus which builds complex events out of states using a small number of event construction operators. The operators \( \text{BECOME } p, \text{ END } p, \text{ and REMAIN } p \) are definable in terms of von Wright’s \( T \) operator as \( \neg pTp \), \( pT \neg p \) and \( pTp \), respectively. Achievements like \textit{find} or \textit{forget} are defined as changes of state, ‘come to know’ or ‘stop remembering’. More complicated actions are obtained by composing the operators. Accomplishments like \textit{kill} or \textit{paint} introduce a further operator \( p \text{ CAUSE } q \), for instance \textit{John does something \text{CAUSE BECOME } \neg \text{Bill is alive}} and \textit{John paints a picture} has the form \textit{John paints \text{CAUSE BECOME} \text{a picture exists}}. Agency is finally brought into the picture with a further reflexive operator \( \text{DO} \). For instance, \textit{look} and \textit{see} are distinguished by \textit{look} having the logical form \( x \text{ DO } x \text{ see } y \) and the activity implicature of \textit{John is being obnoxious} is said to involve \( \text{DO} \). Dowty does not give an explicit semantics to \( \text{DO} \), but says it implies controllability. The operator \( p \text{ AT } t \) relates an event to a time. Vendlerian aspect classes are then tentatively defined by formulas of the aspect calculus. (More complex combinations of these operators produce finer subclassifications.)

| state       | p            |
| activity    | x DO p       |
| achievement | BECOME p     |
| accomplishment | p CAUSE q  |

Table 29

Dowty’s analysis as described here is geared to diathesis rather than aspect. The key insight is that aspect systematically reflects diathesis. I develop these ideas below in the section on diathesis. The difference between achievements and accomplishments is often related to the presence or absence of causation, and many activities involve agency. However, I don’t think these assignments match Vendlerian classes as directly as Dowty would have it.

For one thing, the definition of activity in terms of agentivity is too narrow. Dowty (1979:165 ) notices the existence of nonagentive activities and considers replacing the agentivity criterion with a motion/change criterion. His main obstacle is that progressive statives like \textit{John is ignoring Mary} seem to involve agency without movement or change. Apparently, the unifying feature here is \textit{dynamic}. The absence of movement in the presence of counteracting forces involves exertion of energy (Comrie 1976:§2.3, Galton 1984:72, Bybee 1994:126). As is well known from Newtonian physics, force and energy are related to movement and change through limit processes and counterfactual considerations (movement and rest are both resultants of counteracting forces). This thought will be developed later in the section on force.

The definition of accomplishments exclusively in terms of causation has similar shortcomings: there are noncausative accomplishments (\textit{fall on the ground}) and causative achievements (\textit{make a mistake}). Dowty’s (1979:184ff) eventual featurisation distinguishes agentive and nonagentive event types, permanent and temporary states, activities, and simple vs. complex changes of state. These distinctions are reflected in my framework as well.

**Aspect as point of view**

In one school of thought, aspect is distinguished from tense by saying that tense is deictic but aspect is not (Jakobson 1957, Comrie 1976, Lyons 1977:705). There is another school of thought which regards

Raible (1990:195) for one, following Bühler (1934), defines aspect as a deictic category. Like many other authors of this school of thought, he distinguishes between a descriptive category Aktionsart and the indexical category of aspect. In his view, aspects and tenses are deictic because they refer to the speaker, whereas Aktionsarten do not. Tense locates the narrated event with respect to the speech event, aspect locates the speech event with respect to the narrated event. The “imperfective” aspect means that the viewpoint of the speaker is inside the action whereas the perfective aspect is an action seen from the outside. What is seen from the outside is seen as a whole, as a closed unit. Smith (1991) develops a two-component theory where lexical situation type cross-cuts perfective-imperfective viewpoint aspect.

Perspectival or viewpoint aspect results when event type is composed with reference time:

Aspects are relational in the sense that they represent events by relating their limits to some point of view, an orientation point, abbreviated O. Expressed in localistic terms, such points of view can be situated inside or outside the global event. ... Most markers are combined aspectotemporal markers that determine events with respect to both aspectual and temporal coordinates. (Johanson 1998)


…the perfective looks at the situation from outside, without necessarily distinguishing any of the internal structure of the situation, whereas the imperfective looks at the situation from inside, and as such is crucially concerned with the internal structure of the situation. (Comrie 1976:4)

It is a suspicious coincidence that the perspectival distinction should precisely match the aspect distinction. It suggests that the ‘at’ relation is the same in both cases and the ‘in/around’ distinction follows from aspect. Consider

She was asleep when he left.
He left when she was asleep.

This suggests that within/around perspective distinction follows from closedness vs. openness. And it does. The key observation is that a closed event b (change c = ¬scs or cycle o =¬ss¬s) includes its boundaries, so its glb, or interior, takes place in between. Thus if t is simultaneous with b, b is also within the reference time t, i.e. c at t entails c in t. Conversely, if an open or progressive event a = in a is simultaneous with t, then its lub, or closure, takes place around it. In particular, the boundaries ¬a of a are around t, because the closure ¬aa¬a includes but is not included in a. Consequently, a at t entails a around t.

Thus strictly taken, the events related in a foreground-background description such When I entered the kitchen, he was making breakfast, namely be making breakfast and enter, are simply simultaneous: there is a bit of making breakfast which happens at the same time as entering. The reason breakfast making seems to extend around entering - and thus constitutes its background just as the background of a picture extends around the picture - is precisely that be making breakfast is a part of the encompassing event make breakfast. It is this wider entailed event that is the background, not the particular bit picked out by be making breakfast. This account essentially exploits the fact that open events contain events of the same event type (Dowty 1986:48).

Johanson (1998;§7.1.) seems to contradict this line of explanation:
The role of O should not be misstated to the effect that [progressive aspect] only signals an orientation interval for the event, while [simple aspect] denotes the very event. Both [progressive aspect] and [simple aspect] obviously refer to the event itself.

In can agree with Johanson's argument and keep the explanation, for in my account ‘denote’ and ‘refer’ are kept apart: progressive \(X_1 \times X_2 \times \ldots \times X_n\) e denotes an interior \(X_1\) but still refers to the event e.

For another example (Bache 1985:190), take English simple past and present perfect in Leech' minimal pair

\[
\text{Now where did I put my glasses?} \quad \neg \text{where where now}
\]
\[
\text{Now where have I put my glasses?} \quad \neg \text{where where now}
\]

According to Leech (1971:38), "the difference between these two is merely a slight difference of viewpoint: in the first sentence, the speaker's attention is fixed on the moment when he lost his glasses, in an effort to remember who he did at that time; in the second, he turns his attention to the present result of this action, and the question uppermost in his thoughts is "Where are they now?"). This is precisely the difference reflected in the respective formalisations: the course of events is the same, only focus (denoted subevent) differs.

Besides actually denoting different subevents, it is also possible for two event types to have a different perspective by just being different in composition. The denotation is the same, but intensions differ. My relatives and my wife's relatives are the same now, but it makes a difference to her which way I refer to them - just because they could be different. For an example, compare (Bache 1985:192)

I ate my lunch after my wife came home from her shopping.

\[
\neg \text{home home then lunch now}
\]
I ate my lunch after my wife had come home from her shopping.

\[
\neg \text{home home then lunch now}
\]

The two sentences are provably equivalent. The only difference is the different logical form. Similarly, Russian closed aspect skazal 'said' and simple aspect govoril 'spoke' need not denote different events: it suffices for them to allow, and suggest, different variations of the situation.

Aspect as point of view has been studied more closely in discourse representation theory. Kamp (1981b:45-46) points out that exactly the same fact can be reported in French by passé simple and imparfait depending on context, and concludes that aspects essentially function as instructions concerning the way information is presented. A crucial step in the argument is that there is just one maximal period in which Marie satisfies the verb phrase faire la vaisselle, which thus cannot serve to distinguish the two aspects. What I am exploiting is the fact that there are many nonmaximal events of faire la vaisselle related to the maximal one by imperfective aspect. This point is also stressed in Dowty (1986:48):

The inferences we draw in a narrative about which events or states overlap with others in the narrative is not really consequence of the times sentences are asserted to be true, but rather also in part a consequence of the times at which we assume that states or events actually obtain or transpire in the real world, intervals of time which may in some cases be greater than the intervals of time for which they are simply asserted.

The DRT view is detailed in Kamp and Rohrer (1983). One of their examples bears scrutiny here.

Kissinger arriva au Caire le 6 juillet. Deux jours après il partit pour Jérusalem. Il était déjà très fatigué.

Kissinger arriva au Caire le 6 juillet. Dans deux jours il partait/partirait/allait partir pour Jérusalem. Il était déjà très fatigué.

The first example is a sequence of two closed events and an open one. The second has one closed event and two open ones. Kamp and Rohrer note that the closed events are viewed from the outside, from the perspective of the present, while the imperfectives imply a shift of perspective to the time and place of the narrative. This is reflected in the choice of adverbial. Deux jours après ‘two days later’ is anaphoric, dans deux jours ‘in two days’ is anchored. The DRT graphics of the event structures if these examples is isomorphic to one of my alternative formalisations of them:

---

100Kamp (1981b:50) toys with the idea that the passé simple has to denote an atomic event (one which has no overlap with other events in the same discourse representation), but abandons it in the face of counterexamples.
Is aspect subjective?

How a course of events is being looked upon can be shown by the choice of one of the many formulas that are consistent with the same course of events. This is what writers on aspect may mean by saying that aspect is subjective: the same course of events can be described in many alternative ways.

Examples: Smith (1990:§1.2) considers *Il regna(it) pendant trente ans* 'He reigned for/during thirty years' and points out that though both describe the same reign, the viewpoints differ: the passé simple presents the event as closed, while the imparfait presents the episode as open. Both are true partial descriptions of the same event relative to different context indices. Langacker (1987:258), comparing *The road winds/is winding through the mountains* suggests that the choice of aspect of a verb might not be predictable from any objective array of facts concerning the context. That, if true, would only show that two forms fall together in certain cases - and that can be predictable too. In this particular example, Langacker (1987:257) in fact finds good reasons to use one form rather than the other.

But as many have pointed out, *this* does not yet make aspect any more (or less) subjective than any other bit of language (Verkuyl 1993:10-11). Lindstedt (1985:54) makes a distinction between denoting/referring to an event and entailing/implicating one. He points out that failure to make the distinction is one of the reasons why some writers end up considering aspect choice subjective. Whenever there are many ways of describing the same thing, one has a choice between them. What is really meant is that the aspect varies systematically with the point of reference (perspective) taken, and that different aspects may be contextually equivalent, so that the choice between them makes no difference to truth or even denotation (it may still matter for style and other things).

Indexical and contextual, grammatical aspect is more subject to choice of perspective than derivational Aktionsart. It has in fact been a scholastic bone of contention between continental European aspectologists and others whether the elusive aspect-aktionsart distinction involves degree of subjectivity (Forsyth 1970) or degree of grammaticalisation (Maslov 1959). In my mind, this is a distinction without a real difference. Cohen (1989:34) puts it well:

Les grammairiens allemands, qui, au XIe siècle, ont introduit le concept d’Aktionsart, c’est-à-dire de “mode d’action”, l’ont défini comme objectif par opposition à l’aspect proprement dit qui serait subjectif. […] Le temps est en effet défini comme un rapport entre le moment du procès et celui de l’acte d’énonciation. Il est situé par rapport au locuteur. Cette centralité du locuteur a donc été considérée comme subjectivité. L’aspect en tant qu’il concerne le procès lui-même relèverait d’une réalité objective. Mais le point de vue inverse a aussi été pris en considération. La disposition du procès par rapport au moment de l’énonciation ne dépend nullement du locuteur. Elle constitue un fait objectif que celui-ci ne peut que constater dans l’utilisation qu’il fait des formes temporelles. L’aspect, au contraire, peut être considéré comme relvant du choix du locuteur qui a la latitude de donner du procès l’une ou l’autre des représentations auxquelles le système fournit une expression. Ainsi serait-il subjectif. Il n’est donc pas surprenant que les définitions de l’aspect s’opposent diamétralement à cet égard. […] Il est évident par ces exemples que les notions d’objectivité et de subjectivité sont rapportées, dans les différentes définitions de l’aspect, à des termes différents de ces définitions. L’ambiguïté qui en résulte les rend peu éclairantes.”

Tense

Tenses relate events and event types to times. The notion of time is an abstraction of the notion of an occasion, a situation or course of events within which an event takes place. It is not necessary to require that this abstraction be complete (Lindstedt 1985): *now* may well refer to an occasion of some particular type; it might have inherent aspect, for instance.

It has been suggested that tenses are a later and more marked development than aspects, both historically and psychologically (Givón 1982:155). It is certainly common for tenses to develop from aspects. Tenses tend to be more grammaticised than aspects too.
Narratives involve shifting the reference time, the specious present of the narrative. The reference time is the time a sentence is about, the referent of now (or then in a narrative). I shall not treat reference time as an index or point of reference in the sense of modal logic or intensional pragmatics, i.e. an implicit global variable defining a local view of the evaluation situation which successive sentences relate to or shift. I prefer to take a global view, treating reference times as values of local variables associated to each tense individually. The metaphor of shifting reference time only describes the shift of attention from one reference time to another as a discourse is taken in. It is no different from shifting attention from one character to another in the plot with changes of subject. The referent of each tense (its reference time) is located in a complex discourse context in ways not essentially different from choosing referents for (pro)nominal expressions (Partee 1973). There is a number of putative referents in evidence in the surrounding discourse, and further ones can be inferred. There is no mechanism for reference time shift, rather, resolution of temporal reference is part (and parcel) of reconstructing the logic of a dialogue, using tenses and aspects as constraints on possible interpretations. Similar views are expressed in Webber (1988) and Vlach (1993).

Deixis

Frawley (1992:341, cf. Traugott 1978) draws a detailed analogy between spatial and temporal deixis. Deixis defines the position of an object with respect to a reference point in terms of direction and distance. In temporal deixis, an event is located relative to (e.g. within, around) a time frame with respect to a point of reference in terms of direction (before, simultaneous, after) and distance (near, remote).

Deictic or indexical meaning in general and temporal deixis in particular has got a lot of attention in linguistics as well as in philosophy. The logical tradition after Peirce talks about indexicality, that is, words and sentences of which the reference cannot be determined without knowledge of the context of use; examples are words I, here, now. Other philosophical terms include ‘ostension’, ‘egocentric particulars’ (Russell), ‘token-reflexive expressions’ (Reichenbach 1947), and ‘indicator words’ (Goodman). Montague (1968) proposes to identify pragmatics with the study of indexical expressions. Logically, an indexical expression is one whose denotation is a function of some index or point of reference in a model, rather than a function of the model at large. This is clearly relative to one’s definition of a model. An index is a hidden free variable whose value must be fixed by an assignment (such as pointing) before an expression has a definite denotation.

In linguistics, a reference is demonstrative or deictic if it refers to you and me here and now and descriptive otherwise. (Comrie 1985:14-16) The etymology of both Latin indexical and Greek deictic is pointing at something (we can only point at things that are around us). Ostensive reference (another word for pointing) uses acquaintance criteria of individuation based on personal contact, as distinguished from descriptive criteria. Expressions do not divide into indexical and descriptive ones, many expressions are both at once. For instance, here means in this place, yesterday means the day before this day, while we were away can mean at a time before this time at which this speaker and others were at a place different from this place.

Indexical reference is definite and specific: author and audience are supposed to be able to identify the (same) reference (up to the identity criteria applied) in the context of utterance. Besides deixis, definite reference includes descriptive and anaphoric uniqueness, exemplified by the sun and it. The difference between the different sorts is not great. All definite reference is contextual, the difference is only in the kind of context: perceptual, epistemic, or linguistic. Accordingly, one and the same set of pronominal elements are used for all.

McCoad points out an analogy between near and past tenses and near and past demonstratives. (Extended) now and then relate to one another as at this time vs. at that time. Near tenses describe the neighborhood of the time of speaking, while remote tenses are separated from it by intervening events. In fact one could argue that the distinction between proximal and distal deixis is topological rather than metric in space as well. Whether I call a pen this pen or that pen depends not on how near it is in iches, but whether I can reach it, touch it, hold it and possess it. We normally say Take this pen, give me that pen. Give me this pen almost suggests that I am giving it to you first. In general, proximal demonstratives go with my/our neighborhood, distal ones with yours or theirs. It is not demonstrative

\[\text{The distance can be measured by the accessibility of an object by discourse participants. For instance, Finnish}\]
(one does not have to be able to point at it). English that can be both. That in English refers to near past events, this to nonpast events (an extended now; McCoard 1978: 137). That is not true. It was a load of nonsense. It is really like this. That felt great. This is fun. This has been a pleasure. You are going to like this.

In Finnish, the proximal demonstrative tämä is used to refer to a current dialogue (turn), distal demonstrative tuo ‘that’ to a near past one, se ‘it’ is used for others.

Some languages have a tense system based on a three-way deictic division between ordinal units this, next/last, and earlier/later. What the actual units of temporal distance are is negotiable. One can compare such a system to a two-split binary system of spatial deixis here, there, and yonder. (proximal/distal demonstrative vs. nondemonstrative), Chung/Timberlake (1985). The metric remote past distinction bears comparison to pluperfect for its discourse use as well.

Priorian tense logic only has one index, with no provision for definite reference to time. Temporal deictics and anaphors led to the introduction of multiple dimensional tense logics. The logic of now has been studied by Kamp (1971) and Rescher/Urquhart (1971:33) and that of then by Vlach (1973) (Burgess 1984, cf. Gabbay 1976 and Gabbay and Guenthner 1982). An instructive result is Kamp’s that now can be eliminated up to equivalence from propositional tense logic. The proof transposes any sentence with occurrences of now embedded within past or future tense into a sentence where now occurs transparently. When there are no other operators around, there is nothing for now to scope over to prevent the shift of perspective. The only difference between tensed propositions with and without now is perspective. Now does make a difference to truth when it interacts with quantifiers, modalities and propositional attitudes.

**Persons**

Formally, it is possible to characterise deictics in terms of one another. The origin of the deictic system is first person **I**, which denotes the author or source of this event token, the very dialogue move or speech act where the pronoun itself occurs. (Reichenbach’s term token-reflexive for deictics is thus right on the button.) Second person pronoun you denotes the addressee, or the goal, of this move. These definitions presuppose the notions of dialogue game, dialogue move (Carlson 1983), and an analysis of the dialogue move as a communication event type with animate source and recipient. Many appropriate consequences fall out from this analysis.

The rest of personal pronouns can be defined given you and I. Exclusive we and you can be defined as a plural author and addressee **plI** and **plyou**, respectively. Inclusive we is the token join of first and second person **youI**. Third person can be characterised negatively as not us for the inclusive we: ¬(youI). English does not distinguish inclusive and exclusive we, so the English we is their type join, or equivalently, as I and somebody else **IU~I**. Persons are interdefinable many ways, not just the way proposed here.

**Demonstratives**

Starting from the first person **I** we can define proximal here and now as near **I** in space and time, respectively, where near **I** means at x: I at x:

\[
\text{now} = \text{at } t: \text{I at } t \quad \text{here} = \text{at } p: \text{I at } p
\]

and (partially) characterise distal deictics there and then negatively as ¬here and ¬now

\[
\text{then} = \text{at } t: \neg\text{I at } t \quad \text{there} = \text{at } p: \neg\text{I at } p
\]

Likewise for this and that:

\[
\text{this} = x: x \text{ near } I \quad \text{that} = x: \neg x \text{ near } I
\]

These characterisations will be put to work in connection with tense, orientation and obviation.

Finer distinctions are possible relative to a dialogue game (Carlson 1983) where second person is well defined. Finnish, for instance, uses different deictics tuolla and siellä for not near us and near others. Unobvious combinations like come there and go here can also be made sense of as shifts of the

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102. Pronouns may refer to described events or to discourse events. This explains some of the apparent exceptions noted by McCoard.

103. The yesterday past of Bafut (a Bantu language spoken in Congo), Chambow/Tamanji (1994:217) can refer to yesterday, last week, last month, or last year.
reference game (Rangkupan 1992:18). Demonstratives are interdefinable with persons, so one is an etymological resource for the other. Another common source for pronouns are polite third person address terms. Thai is a good example.

Many languages express future in motion verbs come or go (Givon 1973). Which way it goes depends on perspective. The common denominator is that the distance between us and future events shortens with time. Depending which end of the distance is seen in specious motion, either we go toward the future or the future comes toward us. The former, active perspective may be more common than the latter, passive one.

By symmetry, the distance between us and the past grows with time. Past events go to the past, and make their participants appear to come from them when they are done. The deictic origin is in the past with go and in the present with come, so go pasts are distal and come pasts proximal (Rangkupan 1992).

### Aboutness

Many tense and aspect contrasts, for instance, present perfect and simple past seem to involve what the sentence is about (Carlson 1983): the present perfect is about the present time, the simple past is about the past: (Lindstedt 1985).

That it [the perfect] is a variety of the present and not of the past is seen by the fact that the adverb now can stand with it: “Now I have eaten enough.” “He has become mad” means that he is mad now, while “he became mad” says nothing about his present state. “Have you written the letter?” is a question about the present time, “Did you write the letter?” is a question about some definite time in the past. Note also the difference of tense in the dependent clause in “He has given orders that all spies are to be shot at once” and “He gave orders that all spies were to be shot at once.” (Jespersen 1924:269)

It only becomes obvious what is being talked about when more than one thing is said about the same thing (Carlson 1983). There are two different, but dually related ways in (natural or formal) language to say several things about the same thing. One is variable sharing, the other is function composition. I detail this in the section on anaphora.

My calculus allows both idioms. For instance:

He noticed the lock that had been broken.

He has become mad and talks to himself.

The first formula is a proposition which talks about the same time by containing references to the same event variable then across a propositional connective. The second one denotes the same time by inverting perspective so as to bring a subevent to focus and then intersecting the denotations of two events. Examples of the first method in natural language are reflexive and anaphoric pronouns. An example of the second method in natural language is voice.

The event type e then now denotes the whole course of events from e to now but refers to e. The event type e now entails the course of events from e to now but denotes the past event e. It is always possible to translate from one representation to the other. I use event abstraction to represent nonfinite relative tenses and variable identification to represent finite and absolute tenses.

Tenses or phasal aspects may thus differ only in denotation: they entail the same course of events, but denote or refer to different phases of it. Here are some examples.

- A simple past e now can be narrowed down to a narrative or definite simple past e then now alias e now or to an existential perfect e then now alias e now.
- A near past e now can be narrowed down to a definite near past e now or to a near perfect e now.

The referential distinction is reflected in discourse (vide infra). Present perfects take part in present tense arguments: For instance, an existential perfect can contradict an open near past, and a present state can entail the negation of a result perfect.
There is an interdependence between aboutness and definiteness. According to the definitions of aboutness in Carlson (1983) and definiteness in Carlson (1988), a sentence is about an object if it addresses the question what that object is, while a phrase is definite relative to an identity question if it provides an unique answer with respect to the identity criteria of the question. Relations between aboutness, definiteness, uniqueness, and perfectivity are developed further in the section on definite tenses.

Aboutness comes close to Johanson's (1998) focality, a scalar notion defined as concentration (focus) of psychological interest. If 'psychological' is taken in the traditional grammatical sense of psychological subject, this is aboutness. A difference in treatment is that aboutness in Carlson (1983) is relative but not comparative. But it seems that Johanson's comparative scale can be defined on basis of the distinctions made here.

Aboutness is one aspect of what is in typological literature known as topic tracking or reference tracking. It will come up again in the chapter on diathesis. For categorial treatment of coreference, cf. Szabolcsi (1990).

**Definite tense**


**Teacher:** Bobby solved problem seven. **Suzy:** No he did not, he had already solved it at home.

Suzy is not contradicting the event, only its timing. The argument would sound odd in present perfect.

Why should quantifier character depend on aspect? That there is an entailment from definiteness to closure is obvious. Individual temporally definite events are trivially closed, because they only occur once. This simple observation immediately suggests its contraposition (Leinonen 1982): indefiniteness is a consequence of open aspect. What looks like an existential past tense can be the past tense of a disjunctive event type. For instance, he has been in London is indefinite because it represents (~London.London.~London?)now, so either he has been in London all the time up to now, or he has been in London and is back now, or he has visited London once or more, in which case nothing is implied about his present whereabouts. Indefinite time reference (existential quantification over events) is due to iterative aspect (which is really a special case of existential quantification), just as definite reference involves a contextually unique event type.

Following Leinonen (1982), I will propose that the Russian imperfective is defined as prog e which covers as special cases various uses: progressive, iterative, and existential. A perfective past in Russian, in contrast, tells that a closed token of the event type has been completed and thus its result obtains now (result perfect reading) or that it occurred at the time of a narrative and its results held then (narrative reading). This is vagueness rather than ambiguity, because obviously a past time either extends to now or it does not. Russian does not mark the difference, languages with a perfect do.

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**Note 1** Note the use of simple past I didn't go out. The perfect I haven't gone out is slightly awkward because obviously I am not out now. I haven't been out would avoid this problem.

**Note 2** A temporally definite event type denotes an event token (is a unit event type). Cf. the notion of temporally definite statement in Rescher and Urquhart 1971:21
The English simple past is not perfective, but it is definite. Definiteness by the famous Russellian analysis presupposes denotational uniqueness, uniqueness in turn is defined by an existential-universal quantifier prefix and identity: there is an individual such that any individual is identical to it. Uniqueness is the special case of quantification where the difference between existential and universal quantification and singular reference vanishes.¹⁰⁶

The Russellian explication of definiteness has been criticised for missing the pragmatics of the notion. In my view, the logic and the pragmatics of definiteness are two sides of the same coin. Uniqueness is the logical limiting case of definiteness, conversely definite reference is an instruction to narrow down the context until the reference is unique. In assertion, you match an expression to a context, in presupposition, you match the context to fit the expression. This process is called accommodation by Lewis 1975, cf. Schopf 1987:180. Barwise and Perry (1983:83 ) in fact define the context of an event type as a situation which renders definite references unique. It is not difficult to show that uniqueness and definiteness come down to the same thing in our definition of the English simple past: e then <now is equivalent to e then once <now, simply because e then can only occur once, given a fixed denotation for then. We don’t say He died (just) once (just) then, because it is a tautology.

Jespersen noted the use of habitual near past used to in reference to a definite but unspecified open event in the past, corresponding to once on closed events (Kuhn 1989:518):

I used to live in Chelsea / I once lived in Chelsea / I once visited Chelsea.

Used to weakly suggests that Chelsea was the last place where I lived before now, contrasting Chelsea ¬ Chelsea.now with once ¬Chelsea.Chelsea ¬ Chelsea <now. This latter explication correctly predicts the slight oddity of I once lived at home. On the other hand, the earth was once devoid of life does not seem too odd, at least no less than used to be. The near past used to seems slightly out of place with remote events.

Compare also England is not what it was where the present tense defines the past to England is not what Germany was which raises the question when.

The connection between definiteness and uniqueness ties up with our observation that perfective aspect ¬ e e e makes an event e unique within its reference time. An event token e is equivalent to its own perfective ¬ e e e. A closed event fits a loose reference time tightly without feeling indefinite or anaphoric just as long as the event is unique in its reference time:

John went to a private school. (i.e. when he went to school, which was just once, Vlach 1981).

And so it happened that on a warm windy evening I drove over to East Egg to see two old friends whom I scarcely knew at all. (Fitzgerald, The Great Gatsby)

‘E assim aconteceu que, num fim de tarde quente e ventoso, me meti de automóvel a caminho de East Egg, para ir visitar dois velhos amigos que, a bem dizer, mal conhecia.

The English has a simple past accomplishment and the Portuguese an incentive achievement. The common feature is that the time reference is fully sufficient. No further question as to when during the evening the drive took place arises here, although the drive did not take all evening. We can assume that he went there just once that evening, and that makes the reference definite.

In contrast, a progressive I was driving would feel dangling without a tighter indication of the time. Here, a further question while when? inevitably arises. The reason for the feeling can be explained by looking at the formal translation prog drive]in evening. It translates to in drive]in evening and further to (t:drive]t<)\{t:evening\}t<. The time t denoted by this event type is a shared subevent of both the drive and the evening. Why single it out from the entire drive unless there is something else to say about just that bit?

This is an old observation. Poutsma (1921, citing Sweet) says that the present progressive He is writing a letter is a complete statement, not in need of a temporal specification, while present tense He writes a letter is incomplete and needs some complement like every day, now and then.. The situation is the opposite in the past: Open He was writing a letter yesterday feels incomplete, expecting a tightening like when I entered the room, while closed He wrote a letter yesterday is complete, requiring no further designation of the time of writing.

Predictable: now]letter is a good match between two states. now]letter is marked, for it makes now match a closed event, as in a stage script. The additions every day, now and then turn letter writing into a habit, which is an open event type again. then]letter is a good match between two closed times.

¹⁰⁶ In game theoretical semantics, uniqueness is the situation where a language game of identification without perfect information has a solution.
while then\textit{in letter} leaves the choice of subevent dangling as just explained. Note that plural object \textit{He was writing letters yesterday} is able to remove the feeling of incompleteness by changing the scale of the activity to span the entire day.

Jespersen (1931:179) made the same observation. In \textit{He is hunting} ‘

\begin{quote}
the hunting is felt to be a kind of time frame around something else; it is represented as lasting some time before and possibly (or probably) also some time after something else, which may or may not be expressly indicated, but which is always in the mind of the speaker.
\end{quote}

And Smith (1991:128): “imperfective sentences seem incomplete in isolation, although they are not ungrammatical. … A temporally related situation, temporal adverbials, or contextual information can provide such an anchor.” Robberecht (1998:134) makes the same point.

Berthonneau/Kleiber (1994:48) report the same contrast in French between imparfait and passé composé:

\begin{quote}
C'est pourquoi on peut avoir, sans aucun sentiment d'incomplétude, un passé simple localisé par un adverbe temporel, comme dans
\begin{quote}
L'année dernière Jean escalada/escaladait le Cervin. 'Last year, Jean climbed / was climbing Mt.Cervin.'
\end{quote}
\end{quote}

Similarly Löbner (1988:168) for German:

\begin{quote}
Im Gegensatz zu perfektiven Aussagen erfordern imperfective Aussagen immer eine Bezugszeit, zu der der besagte Zustand herrschen soll. Perfektive Aussagen involvieren dagegen keinen weiteren Zeitparameter. Sie führen stattdessen Ereignisse ein (die freilich ihre Ereigniszeit als ableitbare Größe mit sich tragen).
\end{quote}

Lindstedt (1985:83) notes it in Bulgarian between aorist and imperfect:

\begin{quote}
a definite time adverbial further specifies the time reference of the verb, whereas with an imperfect it either establishes a new point of reference or else is coreferential with the reference point already established by the context.
\end{quote}

Panitz (1998:30) feels that one cannot decide the truth of \textit{Yesterday John had a pizza} without knowing what time of day is being talked about. I disagree: the sentence is true \textit{simpliciter} if John had a pizza anytime yesterday, and false if he had none. What is true is that one \textit{can} mean a particular meal, but that is not necessary. There is a difference between count and noncount event types here. While open event types (\textit{Did you sleep well last night?}) are vague in the same way as noncount terms are (\textit{Was the weather good?}), closed ones (\textit{Did you wake up last night?}) are discrete in the same way as count terms are (\textit{Did you see anybody?}).


When uniqueness within a given reference time cannot fix the reference, some narrower reference time has to be imputed which does. Consider I bought a hot dog. The sentence could answer the questions \textit{Where did you eat today?} or \textit{What did you do with the money last week?} but hardly \textit{Have you ever tried junk food?} Here, there is a strong urge to add \textit{once} to the answer. It is not proper to assume uniqueness when existence is at issue. If one wants to point it out, it must be asserted: I only once bought a hotdog.

Diver (1963) points out that nominal and temporal definiteness pair up. Natural associations (assuming gifts are given just once) are

\begin{quote}
I have received a new pen as a gift.
I received the new pen as a gift.
\end{quote}

The definite pen implies a definite time of giving, while the news of a gift cannot assume the time of giving is known. I return to definiteness in the sections on evidentiality and on discourse. Compare also the sections on the English simple past and present perfect.

There is thus a connection between definite, perfective and remote past. It is not an entailment, for instance American English simple past and Portuguese perfeito can place an event immediately before the present. The connection seems to be this. A perfective past \textit{pf e < now} unpacks to \textit{¬ee e<now} which covers both definite near past \textit{¬ee<now} and simple past \textit{¬ee<now}. In the simple past case,
the perfective is unique only relative to a contextually given reference time *then*, i.e. it is definite: `pee e@then<now`. This is why perfectiva pasts `pf e@then<now` are apt to be contextualised and conventionalised into `pf e@then<now`, as has happened with French *passé compose*.

**Tense and perspective**

The time line is divided by the present into the past and the future. This topological idea has definite implications to the aspect type of the past, the present, and the future. Augustine (*Confessiones XI, 14.17, Thelin 1990:96*) notes the present has no extension. The present is a *boundary* separating, but also bounded by, the two half closed regions of the past and the future (G.Carlson 1977a:426ff). As a boundary, the present instant has no minimum size; it can be contracted to a point, while the past and the future are open in the free direction. On the other hand, in our vague topology, it is not necessary to contract the present to a point. Rather, the present is a family of nested *neighborhoods* of various size converging to a common cluster point *here* and *now*. As noted, this makes the present as an event type a state (open and simple). The time of utterance (“as I am speaking”) is is an open interval of no minimum duration, so an event that is to match it must be a state too (Hirtle 1975:95, G.Carlson 1977a:424-432, Johanson 1998:§7.1). For instance, adverbials of duration seem peculiar when reference is made to the present moment:

> I am worried because the baby is asleep a long time now.

> When I rang him, he was in bed all day.

The sentences make sense if the duration of the reference time (*now, when*) is stretched enough to match the event time (habitual reading).

These observations establish a sort of a *minimal system of tense of aspect*. According to it, an event is either happening *at present*, surrounding the vanishing point of the *hic et nunc*, or it is placed *in* the past or the future, as a closed region separated from the present, apt to vanish to a point in the vastness of time on either side of the present. Thus present events are *around* us and imperfective, while past and future events are *outside*, *separated* from us and perfective. This unmarked tense and aspect system serves languages both ways: a language can get by just expressing the tense or aspect half of the correlation, the other half will be assumed in absence of evidence to the contrary (Galton 1984:13ff, Comrie 1985:36ff, Lindstedt 1985:165ff, Löbner 1988:167).

In order to establish a different view, a *new point of view or perspective*, a new narrative present or deictic centre (Comrie 1976) has to be fixed, from which the past or future of that *then* will look the same as they do *here* and *now*. Thus an additional degree of complexity is brought in when aspect does not agree with tense. Past or future imperfectives induce a new reference time, the specious present of a narrative or an imagined future occasion (Langacker 1982:288, 1987:259). This is why imperfective is characteristic of free indirect speech, a narrative in the scope of an implicit *(someone) thought that* (Santos 1996:349). Conversely, the simple present of closed event types denotes a point of reference not coincident with a present state: performatives, generics, blow by blow accounts, historical present, future.

These considerations explain the observation by Dahl (1985, 1998), Bybee and Dahl (1989) and Bybee et al. (1994) that the typical system with a perfective aspect is a tripartite system where perfective is restricted to the past and the imperfective divided into present and past - or, turning the figure around - the perfective-imperfective distinction is applicable in the past but not in the present.

**Relative tenses**

Use of tense, aspect and mood to relate events temporally to events other than the speech event is - somewhat misleadingly perhaps - known as *relative* tense (*taxis* in Maslov 1989, Thelin 1990), in contrast to *absolute* or indexical tense (Comrie 1976, Chung/Timberlake 1985). The referencing event is usually semantically and syntactically subordinate to the referenced event. The archetypical context is indirect discourse (complements of *verba sentiendi et dicendi*). In general, relative tense helps embed an event in an intensional (nonfactual) context; where absolute tenses have factual entailments. In the following, the choice between relative (present) and absolute (past) tense goes with the choice between ‘notice how’ (perception) and ‘notice that’ (fact). Thus in Russian:

> Ja chasto *zamechal, kak/cho na zasedanijax* Prixod’ko *pergladyvajetsja/pergladyvalsja* s Penchenko. ‘I often noticed how/that at meetings Prixod’ko would exchange/exchanged glances with Penchenko.'
Southern Paiute (Sapir 1930) has separate tense morphemes for relative tense in dependent clauses. Nonfinite forms (participles, gerunds) are widely used as relative tenses in contracted clauses (Finnish, Lithuanian, Latin, Greek). Relative uses of tenses can be morphologically indistinguishable from absolute uses, though relative uses of tenses may obey sequence of tense constraints (English). For English sequence of tense vide infra.

Reduction of tense/aspect distinctions in subordinate clauses and nonfinite constructions is common (neutrality or tense interference, Chung/Timberlake 1985). I return to this in the section on nonfinite forms.

Near and remote tenses

Remote past $e\neg\text{now}$ and immediate (near) past $e\neg\text{now}$ are special cases of simple past $e\neg\text{now}$, and similarly for remote and near future $\text{now}\neg e$ and $\text{now}\neg e$ (Ar. Phys. 222a:20ff). Generalising further, inclusive near past $e\neg\text{now}$ splits into remote past $e\neg\text{now}$, near past $e\neg\text{now}$ and extended now $ef\neg\text{now}$. In terms of the event topology, a near tense is one which relates an event as not separated from now. A remote tense is one where the event is properly separated from now. A tense unmarked for remoteness allows both. A tight (universal) near past until now $\neg\text{now}$ is dual to a loose (existential) past before now$\neg\text{now}$, equivalent to $\sim\text{now}$. A loose (existential) nonfuture by now $\neg\text{now}$ is dual to a tight (universal) nonfuture already $\text{now}$.

The distinction between near and remote tenses is thus in the first place based on the topological distinction of adjacency vs. separation of events on a given level of resolution rather than metric notions of distance in time (Klein 1994:65). It is a matter of grammar whether near tenses are classified as tenses or aspects. The perfect is an aspect for most people. Galton (1984) calls near future prospective aspect. Cf. section on phasal aspects.

Relative to a given resolution, a near tense says that an event is going to happen practically immediately: nothing else worth noting (i.e. nothing in the same course of events and on the same level of resolution) intervenes. A remote tense puts the event further off, allowing intervening happenings. As always, choice of expression and point of view mutually constrain one another, i.e. a given understanding of the events goes with a given tense, and one can be judged by the other.

In English, near future is expressed by be going to. It is going to explode is a more urgent warning than It will explode. (Klein 1994:104). Literally, be going to of course means ‘be taking steps toward something’, i.e. there is a suggestion of something already taking place which will lead to the event in the future. He is going to be famous (sooner or later) thus suggests that a process is already on the way which will eventually lead to fame. The state and its preparatory process here form an immediate (though arbitrarily long) future of now. (Here again, I stick to the literal topological sense of immediately rather than its metric connotation shortly.)107

According to Vinay and Darbelnet (1975:§114) the difference between two future expressions in French je vais dire/je dirai ‘I am going to tell him!’ will be telling him’, is a difference between immediate and remote future, i.e. now.e and now.e. According to Santos (1996:182) the Portuguese future is a rather restricted remote tense. Portuguese too has an immediate future ir+inf ‘be going to V‘ (Hundertmark 1982:§8.251): Vai, Santiago, sirva-se… Vai ver que delicia! ‘Go ahead, Santiago, serve yourself… You’ll see how delicious it is.’

Vet (1983) argues that near tenses extend to the reference time from the fact that it makes sense to point and say Regarde! Pierre a disparu / va s’éveiller ‘Look! Pierre has disappeared / is going to wake up’, while one would not say Regarde! Pierre disparut / s’èveilla. ‘Look! Pierre once disappeared / will once wake up’. There must be something in the present situation that connects up with the event.

A correlated difference is that only near future has a free (indicative) past tense: compare Pierre allait s’endormir quand le téléphone sonna / a sonné ‘Pierre was going to fall asleep when the telephone rang’ with Pierre s’endormirait quand le téléphone sonna / a sonné ‘Pierre would fall asleep when the telephone rang’. A past remote future is a bound tense of indirect speech: Solange était certain que Georges oublierait tout ‘Solange was certain that Georges would forget everything’.

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107 Gabbay and Moravcsik (1980:73) say we are likely to use is going to when we express the belief that something is going to happen tomorrow because we see it starting now. Joos (1967:141) considers be going to the exact mirror image of the perfect. Apud Jespersen (1949:§14.2.3), “limitation of future action to the immediate or very near future is indeed a function of the going to future”, but “by far the most common use of the going to future is its employment as an auxiliary of intention ... intent, plan, resolution or determination ... “
French *Il vient de arriver* ‘He has just arrived (lit. he comes from arriving)’ is an immediate past, as is the Portuguese *acabou de chegar* ‘He has finished arriving’ (This is ungrammatical in English because *arrive* is not an accomplishment).’

An important insight (McCoard 1978, Abusch and Rooth 1990) is that the English *present perfect* is a tight near tense. The event and its result state form an extended now, a near past contiguous to the present.

Comrie (1985: 83ff) notes the similarity between the present perfect and near tenses but reserves the latter term for metric tenses. He suggests Spanish present perfect is a hodiernal tense: *Hoy he abierto la ventana a las seis y la he cerrado a las siete* ‘Today I (have) opened the window at six o’clock and closed it at seven o’clock’. This does not yet prove Spanish perfect is specifically hodiernal. One question is whether any present time adverbial, e.g. *this week* would not do as well.108 They do in Finnish. Finnish too allows the perfect here: *Tänään olen avannut ikkunan kuudelta ja sulkenut sen seitsemältä.* In Finnish too, there is a difference between present and past adverbials; ‘this week/year’ act the same as ‘today’ and different from ‘yesterday/last week/year’. The latter are possible, but evidential. English prefers the simple past in both cases. To me this shows that Spanish and Finnish are weak near pasts, while English present perfect is a tight one.

*Lately* or *just* are near past adverbs, *presently* or *immediately* near future ones (Ar.Phys. 222b9-14), *recently* is a loose one dual to *lately, soon* the future mirror image of *recently* (Åqvist et al. 1977, Burgess 1984:117). A *law of procrastination* tends to turn near tenses into remote ones (*I’ll be right with you...*). More on these in the section on adverbial aspect.

*Used to* seems to suggest a *previous past*, of the logical form *a-=a-{now* denoting the latest event of type *a* before now. It is not very natural with a definite time like *I used to live in Chelsea last year*.

**Metric tenses**

Metric or quantitative aspect and tense (Comrie 1985, Dahl 1985, Chung/Timberlake 1985, Frawley 1992) is grammaticalised less often. It is sometimes claimed that certain aspect types denote short duration (e.g. the Russian delimitative prefix *po* or the Portuguese perfective of a progressive). I don’t think this is what these forms at least primarily mean: it is rather a persistent connotation of irreputative closed aspect, i.e. *of limited duration*. Limited already literally entails *relatively short* in a topological sense, viz. shorter than what it is limited from. Thus the difference between delimitative *po* and perdurative *pro* (*pochipiat/prochipiat* ‘read some/read all’) is not the length of time but the entailment of (in)completeness (Johanson 1998). The implicature of short/long time in *ru Ja postojal tam vsego chas / prostojal tam celyj chas* ‘I stood there altogether an hour /an entire hour’ (Forsyth 1970:24) reflects not completing ¬2hh¬2h vs. completing ¬hh an expected length of stay.

That is all one needs to say, and in fact often is able to say about duration, given the pervasive phenomena of scale and granularity. The same goes for the descriptive term *temporary* which I take to be a synonym of *limited*.109

The distinction between near and remote tense does not yet entail metric or quantitative tense. A partial order between events and their parts follows from algebraic and topological relations. To have a metric, the next requirement is the ability to compare any two times in size in a consistent way, which means that the relation ‘longer’ must be extensible to a strict order and the relation ‘as long as’ to an equivalence relation. When these requirements are satisfied, the remaining requirement for the existence of a numerical measure is to be able to add two times and compare the result to a third time. Such additivity translates into axioms providing enough small parts of what is measured.. Given additivity, it is possible to define a *measure* of time: a real valued function invariant under linear transformations (the choice of origin and unit of measurement). This produces a metric topology of time.110 Metric tense logics are described in Prior (1967), Rescher and Urquhart (1971), and Burgess (1984).

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108 Catalan has perfect in *aquesta nit ha dormit* ‘slept well (perf) last night’ “since the period in which the events were performed is conceived of as not yet finished”. (Johanson 1998:§8.5.2) *Aquesta* ‘this’ is a proximal deictic.

109 In the survey of Bybee et al. (1994:99) fewer languages use a fixed unit (usually days) and many more make a comparative distinction between immediate and remote (and in some cases, ancient) times. Some have both.

110 A distance metric is a real valued function of distances (pairs of points) satisfying the properties of reflexivity (the distance from here to here is zero), symmetry (the distance there and back is the same),
A finer distinction in contact tenses can be drawn between exterior and interior variants: e.now is an exterior near tense where the event happens just before the time of reference, while \( e<\text{now} \) is an interior near tense, where the event happens in an earlier part of a current time of reference. Symmetrically for future. A hodiernal perfect, for instance, would be now: e<now\( \cap \)today, focusing on now but placing the event within today.

Time is measured by counting the cycles of selected standard iterations, longer ones by movements of heavenly bodies: sun and the moon, the stars, and associated changes in nature, shorter ones by drops of water, the pendulum, clock ticks by based on ever finer types of physical oscillations. Metric expressions of time not difficult to formalise in terms of topological ones like next, given we have suitable units and can express iteration (Prior 1967:106-112, Lewis 1973:110). Because the origin can be chosen at will, the measurement can be relative to the point of speech or to the origin of some other calendar. Because the unit can be chosen at will, we can count in days, months, years, hours, minutes, seconds; the result does not change, though the resolution does. The essential property of a metric tense is that it suggests a particular resolution, fixes the unit of measurement. For instance, the metric distinctions in Bybee et al (1994:98) might be formalised as follows:

<table>
<thead>
<tr>
<th>Tense</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>near past</td>
<td>e.now</td>
</tr>
<tr>
<td>simple past</td>
<td>e&lt;now</td>
</tr>
<tr>
<td>remote past</td>
<td>e&lt;now</td>
</tr>
<tr>
<td>hodiernal past</td>
<td>(e&lt;now)&lt; today</td>
</tr>
<tr>
<td>pre-hodiernal past</td>
<td>e&lt;today</td>
</tr>
<tr>
<td>hesternal past</td>
<td>e&lt;( e&lt;) yesterday</td>
</tr>
<tr>
<td>pre-hesternal past</td>
<td>e&lt;( e&lt;) yesterday</td>
</tr>
</tbody>
</table>

Table 30

Dahl (1985:125 ) reports that the most common metric distinction is a distinction between today and not today. The unit separator can be a night of sleep rather than the wall clock. Metric tense is really nothing but grammaticalisation (obligatory marking) of temporal adverbs, say by affixation to the verb. The fact that certain tenses are compatible or incompatible with today or tomorrow does not yet make the tense system metric, for that much happens in many topological proximal/distal or perfect/preterit tense systems. The tense alone had better entail a given adverb, perhaps be transparently etymologically related to one.

Metric tenses that unambiguously denote larger cycles (weeks, months, years) get grammaticalised rarely. One might also look for aspectual, modal, or discourse distinctions associated with the metric, possibly motivated by etymology.

In at least some languages, the system is better described as a system with a three-way deictic division between this, last, and earlier. This is when the actual units of temporal distance are is negotiable. One can compare such a system to a two-split binary system of spatial deixis here, there, and yonder. (proximal/distal demonstrative vs. nondemonstrative, Chung/Timberlake 1985). The metric remote past distinction bears comparison to pluperfect for its discourse use as well.

The insight here is that metric distinctions of this type are a special case of the topological near-remote tense distinction now-not now, only now has been defined as today (Dahl 1985:136, Lewis 1973:110, Prior 1967:106-112). Interestingly, Dahl (1985:136 ) notes that metric near pasts are often identical or etymologically related to present perfect forms, while metric remote pasts tend to be morphologically simple pasts. (For instance, the French passé composé /passé simple distinction reportedly started out as a deictic distinction today/not today). Similar comments apply to Spanish present perfect. If there is a further metric distinction, it is likely to split not today further into some variant of remote past, for instance (before) yesterday (Frawley 1992:366).

and the triangle inequality (the straight route between two points is at least as short as a route through a third point).

The yesterday past of Bafut (a Bantu language spoken in Congo, Chambow/Tamanji 1994:217) can refer to yesterday, last week, last month, or last year. Cf. also Kikuyu below.
Metric tenses satisfy Benthem’s (1985, 1986) axioms of Quality and Continuity with respect to discrete time (van Benthem 1986:104). Diurnal metric time is obtained by relativising (coarsening) the topological-deictic system to discrete time.

Has English got metric tenses? We already know that English present perfect is hodiernal (well, non-hesterernal): *I have smoked yesterday* is out. One might argue further that English *used to* is a remote past tense (Diver 1963:163), because *I used to smoke today/yesterday* are odd. On the other hand, *used to* is a past habitual, and past habituels are remote on the strength of coarser resolution alone.

English obviously can express metric time, because it has temporal adverbials like *yesterday, today, tomorrow, last month, this month, next month, a long time ago, in the long run*. These are only grammatically different from the metric tenses of some more exotic languages. The main difference is that expression of metric time is optional in English, whereas in a language with metric tenses one has to choose a metric when one chooses to say anything. In practice metric tenses may be loose, sometimes down to something in the style of *current/previous unit of time* (Comrie 1985:23). In some cases, it may be difficult (perhaps even pointless) to ask whether we are dealing with a topological tense distinction with a default metric or a metric distinction with a free choice of unit. A genuinely metric tense should not let outright contradictions of the type ‘it happened today yesterday’ get saved by a change of resolution (Comrie 1985:29). However, such co-occurrence constraints do not necessarily imply that the tenses have a fixed metric; they just show that once the metric is fixed, it has to be followed consistently.

Not unexpectedly, metric tenses develop by specialisation from nonmetric ones and by grammaticalisation from temporal and spatial deictic adverbs (Bybee et al 1994:101). Present perfect is a frequent source of hodiernal tense and pluperfect for remote tense.

A metric tense distinction is discrete in the following sense: the previous metric unit is topologically separated from the next one. *Yesterday* is never adjacent to *now*, which belongs to *today*. This is usually true *de facto*, as there is a night in between. It also seems true *de iure*. Although there in theory is an instant at midnight of today which is adjacent to yesterday, it would not be grammatical to say *Now it has been yesterday* even then.

Simple present

Joos (1967), following a century-old tradition of grammarians, says English (like the other Germanic languages, Russian, and many others) has only two tenses, past and nonpast (Hirtle 1975:§1.6). This usage equates tense with *finite* tense. The nonfinite forms also called tenses express aspect (progressive) or phase (perfect).

The simplest tense pres is transparent, no tense at all. No tense means present tense, in other words, the unmarked choice for unmarked tense is the present. Therefore present is used when time makes no difference, such as timeless truths.

Simple present pres can be defined as $e \cap \langle \text{now} \rangle$ (also written as $e \ \text{now}$). now is an indexical variable denoting a time (event type) of arbitrary length around the deictic center (the here and now of the speech event). This means that now is coextensive with a symmetric extended now, the event type $\langle \text{now} \rangle$ including eternity in the limit, i.e. $\text{now} = \text{now}^*$.

If a language has past but no future tenses, its simple present can be as a nonpast tense now≤. In some cases, a present tense may be able to extend to the immediate past. A near nonfuture tense is defined by $e \cap \langle \text{now} \rangle$ (compare the notion of an extended now in the literature).

We noted in the section on now that now is aspectually a state (simple and open). Languages with a well grammaticalised progressive (English, Portuguese) make use of it to match an ongoing event to the moment of speech. The implicature is that the reference time falls within the event, rather than matches it in its entirety, which means that the assignment is only verified for the moment, though it may hold around it. Conversely, simple present matches the event with now, which implies that now is not timed by the moment of speech.

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112 There are Australian languages which lack left and right but have the cardinal directions. Before people start talking about directions, they have to find out where the north is. On the plus side, they don’t have to care which way they are facing.

113 Morphology may lag behind. In Ao (Dixon 1995), past is morphologically unmarked while present and future are marked.
In languages without a progressive the present does duty for both simple aspect and progressive. An unmarked simple present is thus denotes a symmetric extended now $e \cap \text{now}$ or equivalently, an optional progressive in $e \cap \text{now}$.

**Simple past**

I define the unmarked simple past or preterit tense $\text{pret}$ as in past or $e < \text{now}$. Simple past has remote past $e \cap \text{now}$ and immediate (near) past $e \cap \text{now}$ as special cases. Nothing stops from using simple past for arbitrary recent events (‗just now‘ sense): Oh, now I dropped it. By the logic of markedness, preterit allows for the past to be remote, i.e. does not require that it is contiguous. Then for the most part it will be remote (as time keeps going by), and if in a language a marked near past tense exists, the unmarked past will by contrast be restricted to the remote past $e < \text{now}$. Improper past or nonfuture tense can be defined by $e \leq \text{now}$. This one does not guarantee that the event is past. I shall propose that the simple past in English is a definite past, i.e. the event time is placed in a contextually determined past time $e \cap \text{then}$.

The received wisdom about simple past is that it relates an event to a past reference time (Paul 1886:274, Noreen 1904:12:676, Behaghel 1924:§702, Jespersen 1931:60). The difference between present perfect and simple past has been described by saying that the former marks an event prior to the present, while the latter marks it simultaneous with a past time (Ikola 1949:46).

**Simple future**

Simple future as a tense operator $\text{fut}$ abbreviates in future, equivalent to now$< e$. It has similar special cases, ongoing future now$\cap < e$, immediate future now$e$, and remote future now$< e$. Nonpast is defined as now$\leq e$.

In forward branching time, there rarely is such a thing as a simple future. Cree is a future/nonfuture language which has two futures, one for deterministic events and another for nondeterministic ones.

There is a tendency for past/nonpast languages tend to treat foregone future events on a par with present or past ones. Both are events whose complement is outside the cone of events an agent can reach by its action. We can say during or even before an ice hockey game:

The Czechs win/have won this game now.

meaning the outcome is certain at this point. The representation of this is now$\cap \text{plan(win)}$. Compare section on plans.

Determinism, or bivalence, is regained by quantifying over futures with a forward directed modal. Within the narrower cone of events so constrained, the undecided event becomes deterministic. Whether there is a sea-fight tomorrow may be open, but my plan entails one if the rest of the world plays along.

**Present perfect**

Finite tenses can morphologically combine with a nonfinite perfect aspect. Compositionally, a present perfect becomes perf $e \cap \text{now}$ and a past perfect perf $e < \text{now}$.

This analysis predicts that a near present perfect does not appear with past reference time adverbials: I was there yesterday there$\cap \text{now}$ is consistent but I am there yesterday there$\cap \text{now}$ and I have been there yesterday there$\cap \text{now}$ are not. yesterday is a proper past of today on a discrete scale of days. In a discrete topology, all events are separated (Kelley 1953:52). This must be why a near perfect is not consistent with proper past adverbials in a narrow (event time) scoping either: I have (been there yesterday) (there$\cap \text{now}$) is empty because yesterday is separated from today. yesterday is proper past from the first instant of today. This must be why a near perfect is not consistent with proper past adverbials in a narrow (event time) scoping either: I have (been there yesterday) (there$\cap \text{now}$) is empty because yesterday is never adjacent to the time of utterance.

114 Tichy (1977) is careful to point out that the utterance time is always indexical. In the dialogue A: 
Tom was drunk. B: Indeed, he was drunk. the two sentences uttered at different times express the same proposition. The situation is different with present tense: A: Your zip is open. B: (zips up) It is not open now. B would be facetious without the now because the sentences are about different times.
Remote (existential) present perfect does allow a hesternal adverbial: *fi Olen ollut täällä eilen here[yesterday]<now* is fine as an evidential perfect. English past and nonfinite perfects also allow *yesterday* as event time adverb.

Indexical *yesterday* also blocks the application of unmarked iteration: *He has left yesterday before (there)[yesterday]<now* is not meaningful. In contrast, a remote or existential perfect is consistent with past event time adverbials: *(there)[yesterday]<now*

There are well known “systematic exceptions” to the agreement of past and present indexical adverbials with the simple tenses. Mixing proximal and distal deictics is a stylistic device of ‘lively’ narrative styles (historical present, free indirect speech, quod vide). Space-time metaphor is involved in the newspaper caption noticed by Parsons (1990: 286):

Rep. Mickey Leland speaks with Sudanese refugees at a camp in Ethiopia last April.

Another systematic exception is the evidential (q.v) use of indexical past adverbials with existential perfect in many languages. A third type is the memorising use of simple past (Dowty 1977, Fuchs 1988) where a past tense refers to a past statement, observation or prediction of a fact.

Was it rainy tomorrow? (checking weather forecast)
The meeting was next week. (checking prior agreement)
I had the cheeseburger with onions.
What was your name again?

Pluperfect

There are languages that have a pluperfect but no perfect. The pluperfect prototype was found in one third of the languages in Dahl’s (1985) survey, most of them Indo-European. This is not surprising if pluperfect is a bound remote past. To have the ingredients of a pluperfect a language needs to have a simple past tense and bound, dependent tenses in addition to free, indexical tenses. It need not have a prototype present perfect. Lezgian has two pluperfects, a past perfect and past aorist (remote past perfective). Morphologically double perfects do the job in many languages. Languages without a general purpose pluperfect get by too (Johanson 1998:§8.4). For how, compare Classical Greek and Russian below.

The English pluperfect cannot be compositionally derived as the simple past of the English present perfect (Kuhn 1989:540, Declerck 1997). While the English present perfect appears to be a near perfect, the English pluperfect is the simple past of an existential perfect.

*e<then<now*

This form is entailed by the simple past of near perfect *e<then<now* and entails the past of a simple past *e<then<now* which in turn entails a remote past *e<now*. The near perfect in the past is obtained by contracting < into a point and the past in the past by providing e with a definite reference time *then*. Pluperfects get used without antecedent reference in contrast to the perfect to suggest that a reference time is over. The past reference time implicates a point of no return. Examples of such use are:

We had hoped he would recover (but he did not). (Jespersen 1954:84)
We had intended to go to Wales this summer (until there was a change of plan). (Hornby 1954:104)

*gr O papús mu ixe pandreftí tesseris fores. ‘My grandfather (had) married (pret perf) four times.’* (Hedin 1987:22, Johanson 1998:§5.2).

This may point the way pluperfect has evolved into remote past in many languages. Pluperfects allow past location time adverbials on event time as well as reference time (Comrie 1976:56, 1985:66, Johanson 1998:§8.4). However, as Fladernik (1993:181) notes, pluperfects do not participate in temporal *obstination* (Weinrich 1985:6): a flashback opened by a pluperfect is frequently continued in simple past (Huddleston 1989, Declerck 1991). This would suggest that the event time of the pluperfect is not anaphoric. Cf. sections on tense anaphora and topic shifts.

Schopf (1984:332) and Nerbonne (1982) consider the remote past event time indefinite in examples like *I talked to Fran. She had seen Bob.* Narrative sequences in past perfect flashbacks make Hinrichs (1981) and Nerbonne (1984) argue for a definite past perfect which introduces an additional reference time for the event time. I see no need to posit an ambiguity here. Narrative progression is independent of tense. (Declerck 1994:140)
Tichy (1977:362) points out that the event time of a pluperfect clause is not necessarily earlier than the event time of a main clause simple tense. As he shows, the opposite sequence of events is produced quite compositionally with before in

Tom was drunk before he had finished breakfast. *drunk*<breakfast\m’r*

**Theories of tense**

The distinction between local view/global variable and global view/local variable treatments of tense splits theories of tense into two main strands (Guenthner 1979:201). Priorian tense logics from Prior 1967 up to and including Montague’s pragmatics belong to the former type. Quantifier plus free variable approaches (Reichenbach 1947, Rescher and Urquhart 1971, Partee 1973, Needham 1976, Dowty 1979, Kamp 1981), exemplify the latter type. This is less a controversy about fact than about notation.\(^\text{115}\) Many dimensional tense logics starting with Kamp (1971) combine features from both extremes.\(^\text{116}\)

**Prior**

Priorian tenses\(^\text{117}\) are a special case of normal (relational) modal logic. They involve quantification over points of time past, present, or future relative to now, \(Pp\) standing for ‘\(p\) some time in the past’ and \(Fq\) for ‘\(q\) some time in the future’, with duals \(Hp\) ‘\(p\) always in the past’ and \(Gp\) ‘\(p\) always in the future’. It is possible to define a translation between Priorian tense logic and the formalism of this essay. Basically, moving to temporal logic involves hiding reference times in the structure of the model, so truth of the Priorian past tense \(Pp\) now equals truth of \(p<\text{now}\) simpliciter. Proceeding like this get the following equivalences:

\[
\begin{align*}
Pp & \iff p<\text{now} & Pp\land p & \iff p\leq\text{now} \\
Hp & \iff (\text{past} \cap p).\text{now} & Hp\land p & \iff (\text{past.now}) \cap p \\
Fp & \iff \text{now} \land p & Fp\land p & \iff \text{now} \leq p \\
Gp & \iff \text{now} \land (p \cap \text{future}) & Gp\land p & \iff p \land (\text{now.future})
\end{align*}
\]

**Table 31**

Approximations for many natural language tenses are available (van Benthem 1985:5):

<table>
<thead>
<tr>
<th>Past Perfect</th>
<th>Present Perfect</th>
<th>Future Perfect</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPq</td>
<td>Pq</td>
<td>PFq</td>
</tr>
<tr>
<td>Dahlia had lied</td>
<td>Dahlia lies</td>
<td>Dahlia will have lied</td>
</tr>
<tr>
<td>Dahlia lied</td>
<td>q</td>
<td>Dahlia will lie</td>
</tr>
<tr>
<td>Dahlia has always lied</td>
<td>Hq &amp; q &amp; Gq</td>
<td>Dahlia will always lie</td>
</tr>
<tr>
<td>Dahlia would lie</td>
<td>PFq</td>
<td>Dahlia will be going to lie</td>
</tr>
<tr>
<td>Dahlia would have lied</td>
<td>PFPq</td>
<td>FFq</td>
</tr>
</tbody>
</table>

**Table 32**

But many are missing (Guenthner 1979). In particular, there is almost no representation for aspect (a partial semantics for the universal perfect and none for the progressive) and no provision for definite (indexical or anaphoric) tenses.\(^\text{118}\) The former deficiency motivates interval semantics. The latter deficiency has been addressed by many dimensional tense logics (Kamp 1971, Dowty 1982). The

\(^{115}\) Quantifiers and variable binding can be treated indexically modal logic style using Tarskian valuations as indexes, as suggested by Pratt 1977. Variables can be eliminated by operators as in Quine 1966. See van Benthem 1986:10.


\(^{117}\) I.e. the basic ones usually meant by Priorian tenses. Prior did develop more complex varieties too.

\(^{118}\) Partee (1984:276) notes that Priorian and Reichenbachian accounts of the simple past can be considered opposite limiting cases of the anaphoric account where a simple past tense is true if the event time is included in a past reference time (Kratzer 1978,-Bäuerle 1979,-Hinrichs 1981,-Partee 1984). The Reichenbachian account results if both reference time and event time are instants, the Priorian one if the reference time is all of the past.
additional indices provide interpretations for indexical and anaphoric references to time. A further problem is that there is no provision for temporal adverbials. Dowty (1982) shows how the problem can be overcome in a doubly indexed tense logic reminiscent of Reichenbach (1947). In his semantics, *John left yesterday* is formalised in effect as *yesterday (t:leave at t<now)*, which is well formed in my calculus too. The main difference is that Dowty’s indices are hidden in the semantics of his metalanguage, while I use explicit variables in the syntax of mine.\(^{119}\) Extensions of multiply indexed tense logic with adverbials are also found in Guenthner (1979) and Carlson (1994).

Temporal logic axiomatics is recapitulated in the following table for the past. Mirror image axioms apply to the future. (Burgess 1984, van Benthem 1985).

\[
\begin{align*}
PPq & \rightarrow Pq & \text{transitivity} \\
Pq & \rightarrow H(Pq \lor q \lor Fq) & \text{linearity} \\
Hp & \rightarrow Pp & \text{eternity} \\
Pq & \rightarrow PPq & \text{density} \\
q \land Hq & \rightarrow FHq & \text{discreteness} \\
PPp \land PH\neg p & \rightarrow P(GPp \land H\neg p) & \text{completeness/continuity} \\
p & \rightarrow GPp & \text{symmetry over the present}
\end{align*}
\]

**Table 33**

Total order is transitive and linear. Homogeneous time is either discrete or dense. Real time is totally ordered, complete, dense, and endless. Forwards branching time is transitive but not linear. It also fails the lattice axioms

\[
\begin{align*}
FGp & \rightarrow GFp \\
PPp \land PQ & \rightarrow P(Fp \land Fq)
\end{align*}
\]

**Modal tense logic**

Modal tense logic (Thomason 1984) can be used to formalise the claim that time is backwards linear, forwards branching. Starting with point set time, we want time to be a linear order. We can then study different order conditions on *possibilities or situations*, identified as pairs of possible world and point of time. Recall that a situation is the dual of an event: a situation determines a set of events and conversely. A time is an event type too, or a set of simultaneous situations. (One can draw a categorial diagram of these correspondences.)

I assume that possibilities (situations) form a backwards linear order (Rescher/Urquhart 1971:68). Time, as the order of equivalence classes of simultaneous situations, is a linear order. The smallest tree has three points. Backwards linear time means that such trees are folded: any two past possibilities can be temporally compared. Forward branching time means two future possibilities may be incomparable, i.e. they cannot be pooled in one future.

To separate the time and possibility dimensions, abbreviate modal operators as *Np* ‘It is necessary (holds in all histories) that *p*’ and *Mp* ‘It is possible (holds in some history) that *p*’ and prefix the modally charged temporal connectives of branching time with *M*.

It is not difficult to prove that the assumption of backward and forward linear time equals linear time equals pooling of possibilities, alias necessity of the actual *p→Np*:

\[
\begin{align*}
\text{Backwards linear time:} & \quad MPp \land MPq & \rightarrow MP(MPp \land q \lor p \land q \lor p \land MPq) \\
\text{Forwards linear time} & \quad MFp \land MFq & \rightarrow MF(MFp \land q \lor p \land q \lor p \land MFq) \\
\text{Linear time} & \quad MPMFp & \rightarrow MP p \lor MFp
\end{align*}
\]

---

\(^{119}\)Dowty (1982:54 fn 4) points out that indices could be replaced by distinguished variables.
Pooling of possibilities $Mp \land Mq \rightarrow M(p \land q)$

Linear time says past future $MPMFp$ reduces to past, present, or future (Rescher/Urquhart 1971:90). This is a formal vindication of the need of a branching time treatment for natural language past future. The modal tense logic of branching time has been studied in Rescher/Urquhart (1971), cf. also Galton (1984:§7), Thomason (1984). Essentially, it is symmetric and transitive relational modal logic ($S4$) plus the backward linearity axiom (Rescher/Urquhart 1971:91).

Galton (1984:116) calls an event type $p$ actual if it satisfies $p \rightarrow Np$ and potential otherwise. In forward branching time, actual event types include past events and modally qualified future events.

In the branching future model, possibilities can only diminish, but abilities can increase, as they are existential-universal. In the ability sense, something can become possible (feasible) which was not possible before. Conversely, possibility is the limiting case of ability where the universal quantifier ranges over just one branch, and necessity is that limiting case where the existential quantifier reduces to uniqueness. In convergent, thermodynamic time anything that always may eventually happen will eventually always hold (Thomason 1972, Burgess 1983:130).

Reichenbach

Reichenbach’s (1947) influential system of tenses represents the second type. It has two indices beside event time $E$, the indexical speech time $S$ and an anaphoric reference time $R$. Speech time is analogous to my now and reference time to then. Each tense has all three indices. Tenses differ in the temporal relations of the three indices. For the simple tenses, the reference time coincides with the event time, for compound tenses (the perfects), the event time precedes the reference time.

Sequence of tenses is explained by Reichenbach as agreement of reference times (the principle of permanence of the reference point). Exceptions to sequence of tense obey a more general principle of positional use of the reference point, where an (explicit or implicit) temporal adverbial fixes a new reference time.

As for aspect, Reichenbach makes a distinction between punctual and extended event time to capture the distinction between simple and progressive aspect and recognises a second usage of the present perfect in I have known him for ten years.

Reichenbach’s own analysis of tenses is summarised in the following table (Reichenbach 1947:297, Kuhn 1989:521). The last column but one translates the system to my calculus. The rightmost column presents my own notation.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Reichenbach’s Name</th>
<th>Traditional Name</th>
<th>Reichenbach</th>
</tr>
</thead>
<tbody>
<tr>
<td>E—R—S</td>
<td>Anterior past</td>
<td>Past perfect</td>
<td>e&lt;then&lt;now</td>
</tr>
<tr>
<td>E.R—S</td>
<td>Simple past</td>
<td>Simple past</td>
<td>e&lt;then&lt;now</td>
</tr>
<tr>
<td>R—E—S</td>
<td>Posterior past</td>
<td>(Past future)</td>
<td>e&gt;then&lt;now</td>
</tr>
<tr>
<td>R.S.E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R—S—E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E—S.R</td>
<td>Anterior present</td>
<td>Present perfect</td>
<td>e&lt;then{now</td>
</tr>
<tr>
<td>S.R.E</td>
<td>Simple present</td>
<td>Present</td>
<td>e{then{now</td>
</tr>
<tr>
<td>S—E—R</td>
<td>Anterior future</td>
<td>Future perfect</td>
<td>now&lt;then&gt;e</td>
</tr>
<tr>
<td>S.E—R</td>
<td></td>
<td></td>
<td>now&lt;e´r</td>
</tr>
<tr>
<td>E—S—R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S—R.E</td>
<td>Simple future</td>
<td>Simple future</td>
<td>now&lt;then{e</td>
</tr>
<tr>
<td>S.R—E</td>
<td>Posterior present</td>
<td></td>
<td>now&lt;then&lt;e</td>
</tr>
<tr>
<td>S—R—E</td>
<td>Posterior future</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 34

Reichenbach’s combinatorics predicts too many tenses by distinguishing three cases for posterior past and anterior future. A more parsimonious tabulation is the following one from Janssen 1988:

---

120 Cf. Lindstedt’s (1985:81) discussion of the Bulgarian aorist/imperfect opposition in a Reichenbachian scheme.
In this tabulation, there are three indices ordered in three ways around R, defining nine distinct tenses. Janssen (1988) lists some shortcomings of Reichenbach’s treatment.

- Mapping combinations of past and future tense directly on the time line makes them look three ways ambiguous.
- Restricting adverbials to modify reference time misses the ambiguity of *John had left at twelve o’clock*.
- Distinction between simple future and posterior present is not reflected in grammar.
- Posterior future is marginal.
- Three indices are not enough to define four-point tenses *would have left or will have been going to* (Prior 1967).

There are some obvious ways to improve Reichenbach’s analysis. The first is the use of > to simplify the definitions of past future and future past (Nerbonne 1984, Comrie 1985). Since event types containing both < and > cannot be mapped uniquely on the time line with an order preserving mapping, the price of the simplification is a loss of iconicity.\(^1\) This simplification is well worth the price, for as combinations of < and > are compounded, one otherwise quickly loses track of the different possible time lines consistent with the partial order defined by a tense formula.

\(\text{ Figure 15}\)

Essentially the same desire to loosen up Reichenbach’s time line seems to have inspired the four time-line system of Bull (1963), which is essentially a graphical representation of the partial order defined by < and >. Pruned of distracting detail, Bull’s diagram defines the following partial order of the English tenses: This partial order matches the one defined by my formalisation. For similar graphics see Declerck (1997, e.g. 90-92).

The second improvement is that reference time can be left out where it makes no difference, say simple present and the different simple futures (Bäuerle 1979, Fabricius-Hansen 1984). This option is open if reference time is not a semantic index (a global variable) but a syntactic expression (a local variable). The past future perfect *would have left* missing from Reichenbach’s table is a complementary

\(^1\)The point is not new. Partee (1984:fn18) points out that discourses may define partially ordered temporal structures which have no unique graphical layout. Pace Harkness 1987:45, partially ordered temporal representation does not entail partially ordered time.
indication that three indices are not sufficient either. It involves two reference points in Reichenbach’s notation: leave<then>then2<now, or leave’r>then<now.

As for the ambiguity of future, Cowper-Kuhlen (1987:30fn) justifies separating R and S in English future tense by contrasting Now I’ll see John with I’ll see John tomorrow. This is not yet a proper contrast, for the former is likely to mean I’ll see John now (i.e. immediately). A more convincing proof of a separation of event time and reference time is Now I’ll see John tomorrow as a comment on a change of schedule (Huddleston 1967:787). This is indeed best represented as a mirror image of the perfect now[IS] <see[tomorrow].

Representing anterior tenses as combinations of a finite tense and a perfect aspect yields a better match with the morphology of these forms in English. This does not imply that the Reichenbachian event types should be wrong. They are well formed and true representations of the compound tenses in my calculus, though not the only ones, and not enough for predicting what occurs in languages.

An improvement on Reichenbach’s scheme which allows incorporating the perfect unabridged to the system is the observation (Palmer 1965,1987, McCoard 1978, Absch and Rooth 1990, Vlach 1993) that the reference time of the English perfect covers the extended now <now spanning event time and speech time (a near past).

In the section on definiteness, I note a tradeoff between reference time (e then) and perfectivity (pf e).

A definite event is unique and hence perfective, conversely, use of perfective implicates a reference time in which the event is unique. Some languages (English and Finnish) have a Reichenbachian simple past, others (the Romance languages) have a perfective simple past. In the section on temporal focus, I point out a similar tradeoff between using variables (e<then>now) and lambda abstraction (e’r<now) to indicate what is being talked about. Reichenbach contrasts the present perfect to the simple past using the former notation, I allow both.

Klein’s (1992,1994,1995) time-relational approach to tense and aspect bears resemblances to both Reichenbach’s notations and mine. Klein (1995) distinguishes utterance time (TU), assertion time (T-AST), and situation time (T-SIT) which appear to map on Reichenbachian speech time, reference time and event time, respectively. Tenses relate TU to T-AST, aspects relate T-AST to S-SIT. Going beyond Reichenbach, Klein distinguishes perfective and imperfective by reference to event structure. Telic events are composed of initial state (SS) and final state (TS). A perfective has assertion time overlap both initial and final states (i.e. it denotes a half closed event, an imperfective does not overlap final state.


Numerous Reichenbachian many-dimensional or multiply indexed tense logics have been developed (Åqvist 1976, Åqvist/Guenthner 1978, Bäuerle 1979, Guenthner 1979, Bäuerle/von Stechov 1981, Richards 1982, Dowty 1982, Nerbonne 1986, Hinrichs 1988, Hamann 1989, Ballweg 1991, Panitz 1998). This line of research is weakened by arguments that the number of points that may come up in the evaluation of a sentence has no finite upper bound (Gabbay 1974, 1976, Saarinen 1975), which in turn have led to the reintroduction of variables to tense logic.

**Interval semantics**

A second basis of classification of theories of tense concerns the type of period at which propositions are evaluated. Standard (Priorian) tense logic evaluates propositions at points. The Montague-Scott progressive (Montague 1968, Scott 1970) defined as truth at every point in an open interval is non-Priorian but the apparent quantification over intervals is reducible to first order quantification over points. Guenthner (1979) uses many dimensional tense logic to handle intervals, but the truth definition remains pointwise. Humberstone (1979), Röper (1980) and van Benthem (1982:§II.3). also seek ways to reduce truth at intervals to truth at selected points within them.

Bennett and Partee 1972, prefigured by Montague (1969) and Lemmon (1968:100) and followed by Taylor 1977, Dowty 1977,1979, Cresswell 1977, Kamp 1979, Tedeschi 1981, in fact by most writers since, opt for genuine interval semantics where truth at intervals (convex/connected sets of points) is not reducible to truth at points. The arguments for interval semantics (van Benthem 1985) relate to aspect:

- Bennett and Partee 1972: The inference from the progressive to the perfect may fail for atomic processes because they do not hold of points: I am writing a book may not entail I have been writing a book.
• Cresswell 1977: *John polished every boot* need not mean *John polished one boot after another* nor that he polished everyone at once, the actions may overlap. In *Dahlia sang and danced* the actions need not be simultaneous nor disjoint.

• Dowty 1977, 1979: The difference between simple past and present perfect can be expressed as the difference between proper precedence and overlap with respect to *now*.

Most natural language approaches to tense now use interval semantics or something equivalent (Boolean or topological concepts). Interval based tense logic is less developed than point based tense logic (Burgess 1981, van Benthem 1985, 1986).

A contested issue is what truth of a sentence at an interval (rather than a point) should mean (van Benthem 1985, 1986). Many feel truth at an interval is more problematic than truth at a point. Others think it is obvious. Some point out that it is bound to cause truth value gaps. Hamblin (1971:97) notes that interval semantics cannot get by with two-valued logic:

During an interval, there are at least three possibilities with regard to an elementary statement: it can be true throughout the interval, false throughout the interval, or at times true and at times false. It is possible, that is, that *p* may be true in all subintervals of *a*, or false in all subintervals; but it may also be the case that there is at least one subinterval in which it is true and at least one in which it is false. Even so, there may be some subintervals in which it is neither true nor false. We cannot, at this stage, avoid three-valuedness.

I think any attempt to reduce truth at an interval to truth at some points in it misses the whole point of interval semantics (Kuhn 1989). As Parsons and Vlach (1981) have it, truth at an interval is a primitive no different from truth at a point. (Points are intervals after all.) An event type holds at a time if it matches the time exactly. The relations of truth at, in and for an interval are all different but interdefinable: an event holds in an interval if it holds at some subinterval and for an interval if it holds at every member of a cover of subintervals. Truth at an interval as such is independent of truth at, in, or for other intervals. Closure conditions on other intervals depend on aspect type (van Benthem 1985:42).

Löbner (1988:170) feels *Von Dienstag bis Freitag war ich in Köln* is neither true nor false if I was in Düsseldorf from Wednesday on. I disagree: if I left for Düsseldorf halfway through week, I surely was not in Köln from Tuesday to Friday. Depending on event type and resolution, the sentence may or may not have to be true of subintervals. If we are discussing where I worked during the week, it does not matter where I spent the night.

In vagueness, the common theme is the reduction of a nontrivial Boolean algebra, where a sentence can be entirely true, entirely false, or somewhere in between, to the two-valued Boolean algebra 2. In the fuzzy region between two vague states, the boundary can be drawn in different ways, each producing a total valuation. Clear cases of truth or falsity are those where there is no uncertainty, all acceptable total valuations agree. (van Fraassen 1971, Fine 1975).

The computational turn of the eighties brought a wave of approaches determined to replace infinitary classical and possible worlds conceptions of semantics with constructive finitary models based on partial information (Barwise and Perry 1983, van Benthem 1985, 1986). The basic idea of discourse representation theory (Kamp 1979) is that a text gives instructions to build a small discourse model of events with partial information about their precedence and inclusion relations. The discourse representation is then related, in a second step, to a traditional point (set) structure of time via embedding conditions (homomorphisms). This approach can be seen as an alternative realisation of the ideas of granularity and perspective. Eberle and Kasper (1994:163) working in DRT classify French past tenses in terms of a featurisation consisting of four features, PROGressive, PERFECT, TENSE (past/pres/fut) and TP (past/nonpast). PROG is the (im)perfective distinction, PERF marks the perfect aspect, and TP locates Reichenbachian reference time. As in Reichenbach, the feature combinations do not identify tenses but senses or uses of tenses; for instance imparfait is classed two ways as a present and a past tense. The pluperfect has three readings in this featurisation. Altogether, there are 24 possible feature structures of which four French tenses cover seven. It is not clear what the rest of the combinations are good for or which of them are consistent.

**Tense as agreement**

Vlach, as the former would say that it was true in the past that Max would die yesterday, the latter that it was true yesterday that Max died in the past. The difficulty stems from a treatment of tense as a Prior or Montague style singly indexed temporal operator (Cresswell 1973:195-196, Dowty 1979:324, Nef 1981b:96), which makes past (yesterday) denote a past yesterday instead of the yesterday of now. In my calculus, any scoping will do, as tense, adverbial and verb denote independent event types which combine associatively. die $\{\text{then}\} \text{<now}\} \text{in yesterday}$.

Vlach (1993) proposes a “nonsemantics of tense”, treating tense as a sort of agreement phenomenon. Every sentence gets a temporal adverbial either explicitly or implicitly. Tense helps to determine the temporal adverbial of a sentence by the following convention:

In a sentence about the present (where the top level temporal adverbial is present), use the present tense, and in a sentence about the past (the top level temporal adverbial is past), use the past tense.

Once the top level temporal adverbial is determined, tense plays no further part in the process of interpretation. Tense is claimed to have no exponent in Vlach’s event representation. Making minor notational changes, Max has left is represented by Vlach as

\[ \text{type(e, leave)} \circ \text{agent(e, Max)} \circ \text{in(e, then)} \circ \text{at(result(e), now)} \]

which can be proved to be a notational variant of my formula

\[ \text{Max leave \texttildelow now} \]

Implicit adverbials in Vlach’s treatment do the same kind of jobs as coercion (unmarked aspect shift) in mine. Since in my terms, there is no difference in kind between tenses, aspects, and temporal adverbials, there is a reading of Vlach’s approach on which it is entirely compatible with mine. However, I would say that the contribution of the present tense does show up in the way now occurs in the formula.

In Vlach (1993:270) Max has been here yesterday is represented precisely the same as the Max left yesterday. The only thing wrong with the former is that it violates the agreement convention stated above. For the convention to apply, yesterday has to be the top level adverbial in Max has left yesterday now/this time, but not in Max must have left yesterday now/this time. Why? Obviously, a piece of the puzzle is still missing. I will return to this later.

**Whorfian tenses**

The idea of a basic contrast between a deictic centre of here and now and periphery (there, then) has inspired many writers (Whorf 1938, Heger 1963, Joos 1967, Lyons 1977, Lindstedt 1985, Tobin 1988, Janssen 1994). One of its perceived advantages is to subsume indicative factual past and conditional counterfactual past future under a common denominator, all the more tempting in languages which make little distinction between the two morphologically. According to Joos (1967:121), the modern English remote (past) tense has the categorical meaning the referent is absent from that part of the real world where the verb is being spoken.

These considerations connect the present-nonpresent distinction to the indexical or deictic distinction of here and now (our neighborhood, the place and time near or around us) against the not here and now, those places and times further off, or rather, separated from us, in which we are not (Herweg 1991). I am not talking metaphors here, this is literally what the proximal deictics here and now mean in opposition to distal ones like there and then. It has been suggested that the first distinction in the ontogeny of tense is one between the here and now and the rest (Lindstedt 1985:165ff).

Further distinctions can be made within distal reference. Places and times next to here and now and can be distinguished from places still further off, places seen though out of reach from places not yet, no longer, or never in view. The last mentioned distinction marks the boundary between indexical and descriptive reference, knowledge by acquaintance and knowledge by inference. These demonstrative distinctions divide expressions of time as well as space.

A Whorfian tense system arises from taking the deictic distinction proximal-distal and the epistemic distinction between experienced-noneexperienced as basic, so as to generate the following fourfield:

<table>
<thead>
<tr>
<th></th>
<th>here</th>
<th>not here</th>
</tr>
</thead>
<tbody>
<tr>
<td>seen</td>
<td>present</td>
<td>past</td>
</tr>
<tr>
<td>not seen</td>
<td>perfect</td>
<td>future</td>
</tr>
</tbody>
</table>
Table 36
Hopi (Málotki 1983), one of the American Indian languages on which Whorf (1938, 1950) based his famous thesis of linguistic relativity, grammaticalises future against nonfuture. Within nonfuture, the present-past distinction is aspectual. Cf. Navajo below.
Chung/Timberlake (1985) exemplify Tahitian using demonstratives systematically as tense/aspect forms (nei/na/ra ‘here/there/yonder’ signal progressive/near past/remote past, respectively).

Time adverbials
A large class of irresultative closed events, whose main result is the event itself being complete, are events closed by location, and duration, and absolute frequency adverbials. Johanson (1998) observes that time adverbials do not produce resultatives. This must be because time adverbials are intersective and denote time, not change. Aspectual adverbials like suddenly, finally, eventually come close; I suddenly saw him seems to turn I saw him into a change. Adverbials denote time, and time is an event type. As event types, adverbials too exhibit aspect (Harkness 1985, 1987:101, Matthews 1987, Declerck 1997:§9.3.5). Accordingly, one can test adverbials and event types modified by adverbials for aspect.

Adverbial polymorphism
Temporal adverbials relate events to times (equivalently, event types to event types). Given the way temporal relations are reified into event types here, a relation of precedence between two events e<f can be split into event types in several ways. It can be considered as one event type ‘ e followed by b’, as adjacency between two or three event types e, e<f, or e<f, or again, as a match between an event and a location adverbial e in <t or f in e < or f in e < of e<f.<f.

Polymorphism explains the syntactic versatility of temporal adverbials: it often makes no difference what the syntactic attachment of an adverbial is taken to be. The adverbial from now in She will be asleep in an hour from now can be treated as an independent event type now< intersecting with the event type denoted by the rest of the sentence:

now.((<asleep\in hour\{now\})\{now<\})

However, intersection being associative, we can as well first combine in hour from now to an anchored adverbial and apply that to she will sleep:

now.((<asleep\in hour\{now\})\{now<\}))

Type conversion allows calculating the joint contribution of tenses, aspects, and temporal adverbials to the event type denoted by a sentence. For an example of the combinatorics consider He was here yesterday in yesterday\{here\}then snow. Unpacking yesterday as day’.today ‘the day before today’ and today further as day’.now< ‘day around now’ we get here\{then\}in (day’.day’.now<) <now which after a few conversions produces <here\{then<\}day.day\{now<\}<now, where the contributions of the time adverbial and the tense are superimposed. In fact, the past tense turns out to be redundant (on the other hand, the present tense would create a contradiction).

Polymorphism allows alternative analyses of the same facts. There is a choice between construing one or the other expression as ambiguous when there are duality ambiguities (Kuhn 1989:540-541). My point is that one does not always have to choose.

Superposition of events
In this formalism events, tenses and adverbials combine freely by concatenation and meet, both associative operations. The main constraint is that the result is consistent, i.e. denotes something,. is not empty. Locative adverbials constraining the same event type must have a nonempty meet, i.e. cover some of the same time. He comes today tomorrow does not. This is why Bill wrecked the car last night 3 weeks ago makes no sense but Tom broke his leg on Wednesday as soon as he was released from the hospital is fine.

Smith (1978) assumes that a clause can have only one time adverbial. As a syntactic claim, Smith’s requirement is clearly too strong. The above observations suggest a Boolean reinterpretation: different adverbials constraining one and the same event type must have a nonempty meet. A ban against two
disjoint time adverbials per clause is still too strong, as Smith’s own examples of compound tenses show:122

Next June, Todd will be graduating in a year. \textit{now} \textbackslash June \textbackslash s \textbackslash graduate in year

Last night, Mary had disappeared 3 months ago. \textit{disappear} \textbackslash 3 months \textbackslash r \textbackslash night \textbackslash night \textbackslash now

Here, one of the adverbials (next June/last night) fixes the count time of the second adverbial (in a year/3 months ago). Numerical constraints are beside the point; the main thing is that all event types that are entailed to hold are consistent (nonempty).

It is also too restricting to require that time adverbials on the same event are nested (Declerck 1997:104). This is a characteristic of a calendar system, but does not hold of time adverbials at large. Another counterexample is

We married \textit{after} I finished high school \textit{before} I went to university.

The two half open intervals are not nested but have a nonempty meet. I also allow adverbials pieced together from disconnected parts like

We met \textit{before} I finished high school \textit{and after} I went to university.

This helps making sense of disconnected counts of events like

We met altogether three times before I finished high school and after I went to university.

\textbf{Adverbial classification}


We may first distinguish between the time denoted by the object of a relational adverbial and the time denoted by the adverbial itself. According to one terminology, the temporal adverbial before noon <noon is anchored to noon and denotes morning or <noon (Hamann 1987:34). Harkness (1987:76) introduces a further notion of count time for \textit{t} in adverbial completions like from \textit{t} (on), e.g. \textit{She will sleep in/for an hour (from) now/then}. counts time from now/then.

Generalising over these cases, the denotation of an adverbial can be considered as a function of an explicit or implicit anchor. Many adverbials are constrained as to what times they can or must be anchored to, if they are to make definite sense (Smith 1978:60).

A fourfield of adverbials according to type of anchor seems right (Huddleston 1967, Smith 1980, Hinrichs 1986, Oversteegen 1987). \textit{Speech time anchored or indexical} adverbials like yesterday place events relative to a point of speech. \textit{Reference time anchored or anaphoric} adverbials like on the previous day can only be anchored to a reference time other than the point of speech. \textit{Anchored or relative} adverbials like before can be anchored to speech time or to a narrative present but need an anchor (Harkness 1987:82, Levinson 1983:74). \textit{Definite or absolute} time adverbials like at noon refer uniquely, which means that a sufficiently narrow context has to be found where the reference is unique.

Examples:

<table>
<thead>
<tr>
<th>no then</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>speech time anchored (deictic)</td>
<td>anchored</td>
</tr>
<tr>
<td></td>
<td>last week, lately, yesterday, now, today, tonight, tomorrow, next week</td>
<td>long ago, before, previously, recently, at this point, later on, soon, in a year, in the future, next week, already</td>
</tr>
<tr>
<td>no</td>
<td>nonanchored (definite)</td>
<td>reference time anchored (anaphoric)</td>
</tr>
<tr>
<td></td>
<td>in the morning, at noon, on Sunday, in April, at 8:30 on Saturday November 29th 1997</td>
<td>a week before/afterward/earlier/later, at the time, then, the same/previous/following day</td>
</tr>
</tbody>
</table>

Table 37

122The claim of course dates from the heyday of deep structures when what you saw was not (at) all what you got underneath.
These classifications follow from definitions like \( \text{day} \langle \text{now} \rangle, \text{day} \ ' \text{today} \) and \( \text{today} \ ' \text{day} \) for today, yesterday and tomorrow; \( \text{week} \langle \text{now} \rangle, \text{week} \ ' \text{this week} \) and \( \text{week} \ ' \text{week} \langle \text{then} \rangle \) for that week and the week before, \( \text{June} \ ' \text{–} \text{June} \langle \text{now} \rangle \) and \( \text{now} \ ' \text{–} \text{June} \ ' \text{June} \) for last/next June, \( \text{t} \ ' \text{week} \ ' \text{then} \) and \( \text{then} \ ' \text{t} \) for a week before and later on, and \( \text{pf noon}, \text{pf Sunday}, \text{pf April} \) for definite adverbials.

A second classification of adverbials is as anterior (yesterday, previously), posterior (later on, soon) and simultaneous (now, meanwhile) according as the denotation of the adverbial precedes, follows, or matches the anchor.

**Calendar times**

In a hierarchical calendar system, any two event tokens are either disjoint or nested, so we have nicely nested, stepwise refined event times as in *He will come at 3 pm on August 10, 1997.* The weekday system is commensurate with the day of month system but not in phase with it, so a date like *Saturday, August 10, 1997* can be empty (inconsistent). Other breaches from periodicity in the calendar system generate empty dates like *February 29, 1997* and *February 30.* Clock times are periodic in days, so *at 3 on Tuesday* does not exclude any Tuesdays.

Calendar time adverbials are definite. The definiteness requirement only requires the reference is unique, it does not specify how the context is narrowed down to make the reference unique. There are different ways. In *Last week, he came on Sunday, last week* narrows *Sunday* down to the Sunday that week. In *If they come on Saturday that week, you can come on Monday* is consistent. For clock times, tense is a way to make reference definite.

Since there is one Sunday each week, the *Sunday* is the nearest Sunday future or past of a given anchor. With no loss of generality, one can thus fill in an anchor for \( \text{pf Sunday} \) as the nearest Sunday before/after now/then. With this understanding, *It turned out he (had) arrived/will/would arrive on Sunday* unpacks to one of \( \text{arrive} \ ' \text{pf Sunday} \ ' \text{turn out} \ ' \text{now} \) ‘It turned out he (had) arrived on the previous Sunday’, \( \text{arrive} \ ' \text{pf Sunday} \ ' \text{now} \ ' \text{turn out} \ ' \text{Monday} \) ‘It turned out he (had) arrived last Sunday’, \( \text{arrive} \ ' \text{pf Sunday} \ ' \text{turn out} \ ' \text{now} \) ‘It turned out he would arrive on the following Sunday’, or \( \text{arrive} \ ' \text{pf Sunday} \ ' \text{now} \ ' \text{turn out} \ ' \text{Tuesday} \) ‘It turned out he will arrive next Tuesday’. The upshot of this is that definite calendar times need no syntactic completion to be understood the way they are in fact understood; everything follows from definiteness alone. However, the anchor does not have to be the time of the main clause, it can be some entirely different week. Smith (1978:59) shows how the likely interpretation varies with the context:

> The nurse explained that the doctor was working on Tuesday
> … so he couldn’t have committed the crime
> … so he couldn’t come to the charity bazaar.

Another consequence is that calendar time adverbials define their own resolution: it is the resolution in which they are definite. This has interesting repercussions to the use of point time adverbials with event types of different resolution, discussed below.

Oversteegen notes *He realised on Tuesday that he had been fired yesterday* is funny. The most straightforward reading \( \text{fire} \ ' \text{yesterday} \ ' \text{realise} \ ' \text{pf Tuesday} \ ' \text{now} \) is contradictory: there cannot be a Tuesday between yesterday and today. The otherwise consistent reading \( \text{fire} \ ' \text{in yesterday} \ ' \text{realise in pf Tuesday} \ ' \text{now} \) identifies Tuesday with either today or yesterday. Reference to \( \text{today/yesterday/morrow} \) with a weekday name goes against the shortest access principle of Carlson (1988).

There is a correlation between definiteness of adverbial and the tense that goes with it. *On Tuesday* is definite, \( \text{on a Tuesday} \) and \( \text{on Tuesdays} \) are indefinite. \( \text{He has been here on Tuesday} \) is bad in isolation, but *He has been here on a Tuesday/on Tuesdays/once on (a) Tuesday/on Tuesday(s) so far* are fine. The former has the form \( \text{pf Tuesday} \ ' \text{here} \ ' \text{r} \ ' \text{now} \) which is empty unless today is Tuesday. The latter are of form \( \text{pf Tuesday} \ ' \text{here} \ ' \text{r} \ ' \text{now} \) which is consistent. For clock times, tense is a way to make the difference between definite and indefinite reference: *He was/has been here at eight (then/once/before).*

**Finite state calendar calculus**

Event calculus provides a good formalism for describing calendar and clock times in natural language. Not only can time expressions be defined, but calendar calculations can be conducted using model checking methods on finite state automata (Karttunen et al. 1997, Karttunen/Beesley 2000) Here are example definitions of some basic calendar adverbs.
The ambiguity of \textit{day} can be seen as a case of resolution, a move from the circadian cycle (\textit{day.night})\ cancel to a diurnal one (\textit{day})\ cancel, by taking the quotient (\textit{day.night})/\textit{day} which maps the nights into the null event type.

The definitions also lend themselves to calendar calculations using the logic of regular expressions. Consider for instance a typical statement of museum opening times:

\begin{center}
\textbf{The museum is open Monday to Friday 9 to 15 except June to August 10 to 18.}
\end{center}

\text{Monday < Friday \land 9 < 15 \land June < August + June < August \land 10 < 18}

The extended regular expression notation maps transparently to the natural language idiom here. This is even more apparent when the except clause is expanded to except June to August, when it is open from 10 to 18.

It is now possible to prove that the museum will be closed at nine in the summer months by showing that the meet of the museum opening times with 9\land\textit{am}\land\textit{summer} is empty.

\textbf{Timetables}

The fact that the event calculus contains a linear algebra (see section on matrices over Kleene algebras) means it allows a literal construal of the notion of a \textit{timetable} as a matrix of event types. For instance, a weekly calendar consists of a 24-7 matrix of hours, which can be decomposed in various ways into a number of daily schedules considered as component matrices.

For instance, a conflict in a teacher’s weekly schedules could be shown by the following matrix sum or superposition:

\begin{center}
\text{\textit{lunch daily at noon}}
\end{center}

\begin{center}
\land
\end{center}

\begin{center}
\text{class mon|wed|fri from eleven to one}
\end{center}

\begin{center}
\textbf{ergo}
\end{center}

\begin{center}
\textit{lunch} \land \textit{class mon|wed|fri}
\end{center}
Reference time vs. event time adverbials

Reichenbachians classify adverbials as *speech time, reference time,* and *event time* adverbials depending on what index they denote (Harkness 1987:66-90ff). Speech time adverbials (*now, today*) are anchored to and denote now; reference time adverbials (*yesterday, tomorrow, previously, subsequently*) are anchored to now but denote some other time; event time adverbials are not anchored to anything.

Reichenbach maintained that reference time adverbials always denote reference time (1947:294, cf. Smith 1978:50ff) This is contradicted by the ambiguity of pluperfect sentences like *(We found out this morning that) he had (already) arrived yesterday.* The alternatives are to add a second reference time (Hinrichs 198?) or reject Reichenbach’s claim. In general, a Reichenbachian hypothesis that adverbials should have a fixed association to an equally fixed set of temporal indices seems too restrictive. Adverbials are associated to events, not indices. Hamann (1987) threshes this out in detail.

Following Bäuerle 1979, Harkness 1985, Schopf 1984 and Smith 1978, Hamann (1987:34) uses Reichenbachian terms to divide temporal adverbials into *speech time* adverbials (*tomorrow, now, yesterday*) and *reference time* adverbials (*before, five minutes later, then*). The former group are also known as deictic adverbials. As she notes, calling the second group reference time adverbials seems suspect in the face of examples like the following, where *ten minutes later* counts time from John’s arrival, i.e. the event time of the past perfect, not from our arrival (the reference time).

*When we came home, John had already arrived. He had simply walked in. Ten minutes later he had finished the last of my beer and had started on my whisky. Well, we had a blazing row.*

Hamann’s (1989) hypothesis is that when temporal clauses function as temporal adverbials, the event time of the temporal clause determines the reference time of main clause (except for a number of exceptions). Hamann’s semantics is a Reichenbachian three index system, so she always has two times to choose from, event time and reference time. I try to translate Hamann’s claims to my framework and see whether they hold. I start with

He had telephoned his lawyer two minutes before he left.  
Hans came two minutes before/after John (had) left.

In the first, the call was precisely 2 minutes before leaving; in the second, the distance between arrival and departure is 2 minutes. Hamann takes these sentences to show that one has to measure distances from event time, not reference time.

In my view, these sentences prove nothing one way or the other. The first one can translate either as 

\[ \text{telephone}_r \cap \text{then}_2 \text{min} \text{leave} \cap \text{now} \]  

or as 

\[ (\text{telephone}_r' \cdot 2 \text{min} \text{leave})_r' \cap \text{then}_r < \text{now} \].

In the first translation, the temporal clause modifies the past perfect (before sentential or referent time adverbial), in the second one, the past perfect modifies the whole sentence (before is an event time adverbial). The logical force is the same. Telephoning ends where having telephoned starts, i.e. \( e.e' r \) is a theorem in my calculus.

In the second example, because *come* and *leave* are achievements (can contracted to a point), there is no difference between simple past and perfect thanks to the perfect theorem: 

\[ \text{come}_r \cdot 2 \text{min} \text{leave}_r \text{and the same goes for } \text{leave}_r \cdot 2 \text{min} \text{come}_r \text{and leave}_r' \cdot 2 \text{min} \text{come}_r. \]

Things get more interesting when the event in the *before* clause is extended:

He dropped the letter before he (had) read it.

The pluperfect sentence has two readings represented by \( \text{drop}_r \cdot \text{read}_r' \) and \( (\text{drop} > \text{read})_r' \). As noted in the section on *before,* there is a potential difference here, for *read* and *read* \( r' \) start at different times. With simple past, he dropped the letter before even starting to read it, with the pluperfect, before finishing it. I actually don’t think the correlation is too tight. The reverse readings can be reconstructed too. *Read it* can be contracted to a point, which allows the simple past fall together with the pluperfect. Or the pluperfect has some external reference time.

There is a clear ambiguity too in

After the bout with Tyson, he had won twenty fights straight.

which is ambiguous between twenty fights up and including the bout with Tyson (a win) or twenty fights after it (maybe a defeat). It is not difficult to find examples of alternative scopings. Word order influences scope preferences, but the preferences can be defeated by varying the context.

When John arrived, Mary had left.  
Mary had left when John arrived.
Compare also Hamann’s

When John had arrived, Mary had left.

I do think the sentence can describe overlapping events in the past twice removed. This reading can be represented by \( \text{arrive} \langle \text{then}2 \rangle \langle \text{r} \rangle \langle \text{then}1 \rangle \text{leave} \langle \text{then}2 \rangle \langle \text{r} \rangle \langle \text{then}1 \rangle \langle \text{now} \rangle \) which obviously simplifies to \( \text{arrive} \langle \text{leave} \langle \text{then}2 \rangle \langle \text{r} \rangle \langle \text{then}1 \rangle \langle \text{now} \rangle \). Summing up, there is evidence for adsentential (reference time) as well as for adverbal (event time) adverbials. Unless and until there is some mileage to be had from further restrictions, it seems right to allow both. In other words, I go for what Hamann (1989:58) calls the mixed-mixed approach. Hamann’s impression that before and after seem to prefer event time anchors is a consequence of the perfect theorem. As Hamann (1989:32) points out, this makes straightforward sense of subtle distinctions such as the near equivalences of after and when in pluperfect and after in simple past or pluperfect.

When/after Thelma (had) passed / the pastry shop, she breathed a sigh of relief.  
After/when he (had) returned from work, his wife cooked dinner. (Quirk1972:783)

A curious example is Hornstein’s (1977)

John left a week ago yesterday.

where the the event time of leaving a week ago seems to properly precede the reference time yesterday while the tense is the simple past, against the Reichenbachian definition of the simple past. Hornstein (1979) is able to save the example by construing Reichenbach’s formulas as instructions or partial specifications for building a discourse model (somewhat in the style of DRT). It seems simpler to treat a week ago yesterday here as a combined adverbial meaning a week before yesterday is week yesterday (Harkness 1987:82). Separated, the two adverbials sound much worse: Yesterday John left a week ago A week ago John left yesterday. The sentence does not seem able to answer the questions When did John leave a week ago? or How long ago did John leave yesterday? A pluperfect can support the two adverbials separately: Yesterday John had left a week ago.

**Time adverbials of location**

Adverbials can match an event tightly (at) or loosely (in). Loose adverbials are existential. Tight ones are universal or existential-universal (definite). It is often anybody’s choice whether it is the adverbial or the event that takes up the slack needed for an exact fit between event type and time. A loose adverb does (it denotes events of varying durations), a tight one does not (it only denotes events of the same size as the adverb). Loose adverbials include frame adverbials like yesterday and bounding adverbials in a while, tight adverbials include duration adverbials for a while and point time adverbials at the moment.

A tight fit with a closed time \( t \) or \( e \at \( t \) (equivalently \( e \at \( t \)) produces a closed event type, for \( \at \( t \) at \( t \) is trivially empty (a time \( t \) occurs but once). A loose (existential) fit in \( t \) is bounded but open: in \( t \) in \( t \) entails in \( t \). Progressives come from frame adverbials be a-singing \( < \) be on singing. The interpretation of an adverbial as a tight or a loose fit in some cases depends on aspect and resolution, for instance, whether the progressive fits within the adverbial or wraps around it: I was working yesterday and I was having dinner yesterday.

An obvious but important difference between tight and loose adverbials is a denotational one. A loose use of yesterday in We talked yesterday talk in yesterday wraps around the framed event talk. A tight adverbial makes the event match the adverbial, so the composition matches the frame: We talked all yesterday talk \( \langle \text{yesterday} \rangle \).

We were talking yesterday is vague between in talk in yesterday and in \( \langle \text{talk} \rangle \langle \text{yesterday} \rangle \). The former denotes a point inside talk inside yesterday (leaving it open which point it was), the latter makes entire yesterday a subevent of talking. (Compare the section on definiteness.)

Frame adverbials are exemplified by after, afterwards, ago, eventually, finally, before, earlier, during, formerly, immediately, initially, just (a short while ago), last, later, next, once, originally, previously, presently, recently, shortly, soon, subsequently (Quirk 1974 § 8.57).

**Time adverbials of duration**

Vlach 1993 contrasts temporal location adverbials with aspectual (duration and frequency) adverbials, which are sensitive to event type. Duration adverbials for \( t \) entail tight fit, i.e. for is a special case of
at for noncount event types. Duration adverbials map open events to closed events. English for and from t to u are duration adverbials.

For produces a closed event, because size is not additive: for t, for t is not of type for t, but for 2t. Portuguese uses perfective in Ele dormiu durante duas horas 'He slept for two hours'. As usual, quantifier scopes have to be resolved before applying the criterion. For some time may appear open because existential quantifiers are monotone increasing. It is not when the aspect type is determined by the underlying variable t in the formula in some t: for t. Cf. Carlson 1981.

Vlach (1993:253) argues one should not simply interpret durative adverbials as unqualified universal quantifiers over subintervals:

\[ p \text{ for } t \text{ is true iff } p \text{ is true at every subinterval of } t. \]

One reason is that coarse processes simply don’t satisfy the subinterval property (atomlessness) entailed by the definition, they have atoms. For instance, by this definition, John slept in his office frequently for six weeks would entail John sleeps in his office frequently for every day of those six weeks. Vlach’s point is that the sentence cannot be verified independently for each day so that the truth value sums up for the six weeks. Given any fixed value of frequently, say once a week, there is a minimum resolution for which the claim can be verified, and allowing for averages, the claim may be true for the six weeks even in the presence of an exceptional week. The truth of a duration expression depends on the resolution of the measure. For a fine enough measure, the individual measurements may begin to fail: work for an hour may be true but work for every minute of an hour may be false.

One might try to save the subinterval definition by considering John sleeps in his office frequently a generic event type, a state which holds at every point of the span in which the frequency estimate is verified. This is doubtful, for pointwise frequency estimates like John sleeps in his office frequently today/right now sound odd. The only present time adverbials that are really felicitous here are of vague duration, like now or these days. Apparently, the sentence does not satisfy the subinterval property even as a generic assertion.

Carlson (1981) and Abusch/Rooth (1990, referring to Hinrichs 1985), propose a weaker quantificational condition on for which ties in nicely with the notions of atomicity, extensive measurement, and granularity: e for t is true if e is true at a (some, given, or any) proper cover or partition for t of t by subevents of suitable resolution, i.e. p is true at each member of the cover for t.

A cover for t of a time t is a higher order event type so that t \subseteq \bigcup_t. A partition is a disjoint cover, i.e. t=\Sigma_t. The event type e for t equals \bigcap_t and denotes e \cap t. This means in effect that for t takes a plural or noncount argument.

The minimal proper partition of t is a two-element partition t = u+v. Thus e for t entails e at u + e at v, and e+e at u+v, i.e. e \cap e at t \cap e at t and finally e \cap e+e at t, so e \cap e+e > \emptyset, which contradicts the characteristic axiom of atomicity closed events.

The requirement of proper cover (or partition) guarantees that for does not apply to closed atomary event types. A closed event type is atomary, so it has no proper cover. More than that, the definition of e for t entails that the event type e must be closed under join, i.e. open.

The truth condition for for is an existential-universal condition instead of a simpler (and stronger) universal condition. It has the advantage of not entailing the subinterval property, so it can be satisfied by all open event types, including coarse processes like walk or sleep frequently. It also goes well with the use of for with measure phrases like for fifteen minutes, for fifteen minutes is a proper cover (partition) of a quarter of an hour by one minute subperiods. (I am not implying that fifteen minutes only allows a partition into minutes.)

The definition allows that e for t is true for a coarser cover but false for a finer one. For instance, in a walking competition, there is a definition for walking which ignores a small number of running steps. Protests can be solved only relative to a fixed definition of resolution. It thus makes sense to consider the choice of resolution a negotiable contextual parameter. (Note, for later reference, how this analysis of for matches the computational notion of a for loop. The incrementation condition corresponds to the grain of the partition. The start and stop conditions correspond to temporal from and to (since and until).

Abusch and Rooth (1990 citing Hinrichs 1985, also Mittwoch 1977,1988:220, Parsons 1990:219) make a distinction between (connected) duration adverbials like for (a period of) forty hours and (possibly disconnected) measure adverbials like (for a total of) forty hours. Both interpretations are possible for Mary worked (for) forty hours last week.
but it is more likely to measure a disconnected sequence of working hours within a week. As I allow disconnected event types, I need no formal difference here. Both are represented straightforwardly as $work \cap forty\ hours \cap last\ week$, where $work$, $forty\ hours$ and $last\ week$ all include the same disconnected sequence of events. Compare

For the last twenty-four hours, I have only slept for four hours.

where the first $for$ is a duration adverbial the scope of $only$ and thus equals a location adverbial $in$, and the second one is a measure adverbial ($for$ is optional). Abusch and Rooth (1990) predict that only a connected reading is likely for sentences like

For eleven hours now, John has been asleep.

The reason they offer is that the preposed adverbial measures an extended now which (they assume) is a connected period.

Bennett (1981:21) points out that $in\ t$ may also sum over disconnected times.

John built himself a sailing boat in about 2000 hours of intensive work during three years.

It is possible to learn to fly in less than 50 hours of actual flying time.

Partee’s examples of durative adverbials (Vlach 1993:252) exhibit the same type of presupposition-focus behavior as generic quantifiers.

Mary slept for a week.
Mary slept in the attic for a week.

The first example suggests that Mary slept throughout the week (at least more of it than she would normally do), where the second avoids such an implicature; it only says that Mary’s sleeping quarters were at the attic during the week. The phenomenon has nothing to do with durative adverbials in particular, for it persists on leaving out $for\ a\ week$ or replacing it with $last\ week$. I shall take it up in the context of temporal quantification.

Mittwoch (1988:220) points out a scope ambiguity in

John did not sleep for 12 hours

between John having slept more or less than 12 hours or having been awake for 12 hours: To capture $precisely\ 12\ hours$, we have to take the join of all the sleep on occasion and match that with the time: $\neg(\bigcup sleep \cap 12h)$ vs. $\bigcup \neg sleep \cap 12h$.

Durative adverbials applied to a closed event apply to the result state if any (Dowty 1979, Harkness 1985, Hamann 1989). Durative adverbials cannot measure the change because the change is closed. The modified sentence still denotes the change (it is not coerced to denote the result state).

The machine went off for a moment (The machine was off for a moment). $\neg off.(off\ \cap \text{moment})$

The spaceship entered the atmosphere again. (It was there again.)

$\neg atmospheric.atmosphere.atmosphere$

I have solved the problem for 20 minutes. (It will not bother us for 20 minutes.)

$\neg problem.(\neg problem\ \cap 20\text{min})$

We have to put you on suspension until you are cleared. (You will be suspended until then.)”

He turned away while Lizaveta Petrovna put the baby to the unaccustomed breast. Suddenly laughter made him look round. The baby had taken the breast. (His back was turned away the while.)

Since the 11th inst, the Post Office authorities have discontinued the special arrangements which were in operation in the field. (The arrangements have been discontinued ever since).

He was taken prisoner from the 1st of April till the 15th of May. (Schopf 1987:182).

On this reading, the change has no implied duration. The reading is hard to get if the change is extended. $I\ went\ home\ for\ a\ while$ is ok, whereas a manner accomplishment $I\ walked\ home\ for\ a\ while$ suggests a habit. $He\ left\ London\ for\ Cambridge\ for\ a\ while$ can mean ‘He went to stay there for a while’, but $He\ drove\ from\ London\ to\ Cambridge\ for\ a\ while$ suggests ‘He commuted for a while’. For an accomplishment without an appropriate temporary result state, the adverbial can only measure the event: $I\ read/wrote\ a\ letter\ for\ a\ while$. Reading has no particular result, while the result of writing is normally not temporary (compare $The\ teacher\ wrote\ the\ sentences\ on\ the\ blackboard\ for\ a\ moment$).

This provides a test for distinguishing achievements from accomplishments and cycles and states from acquisitions. In the perfect the result is naturally counted forward from now, i.e. $r$ extends to the future. With closed resultative event types, again can mean back, i.e. repeat the result state. This can be used
to distinguish cycles from changes. A cycle knock again/for a while implies knock repeatedly, come again/for a while can also mean come back/stay a while.

Finnish uses object cases for event duration and a goal case for result duration: nukkua 20 minuuttia/sleep 20 minutes vs. nukahdta 20 minuutiksi/go to sleep for 20 minutes. An object like adverbial of time 20 minutes/20 minuutia only goes with open events, so a goal adverbial 20 minuutiksi/for 20 minutes is the only choice with closed event types.

Long is a comparative duration adverb 'for a long time'. Therefore it differs from absolute duration adverbs like for an hour for being open: the concatenation long.long is also long. Russian dolgo applies to open aspect. The correlation is not absolute for medlenno 'slowly', which is a relative duration/frequency or rate adverb. Precisely the same facts hold in Finnish: Luin kirja/*kirjan kauan I read the book (ptv/*acc) long but Luin kirjan/*kirjaat hiitaasti. I read the book (ptv/acc) slowly. The difference is predictably one between slow rate and long overall duration.

Periphrasis with an open verb to express the duration of a closed event in the style of intransitive b last/take t or transitive x use/spend t to b or is common. (See Chinese and Navajo for examples.)

If the cover or partition in for t is proper, the denotation of for t has proper parts (is complex or extended), hence what it measures (meets) has parts as well. In an atomless Boolean algebra every element is complex or extended (consists of at least two proper parts). The smallest Boolean algebra that has proper parts to support measurement is the four-element algebra 4.

The durative adverbial p for t can be paraphrased in ways well known from programming logic:

p while in t
p from \<\t to t\>\<\n
These forms also entail that p can be partitioned into parts also in p. The former entails p while u for parts u of t. The latter unpacks to p at u\>p at v for a prefix u and a suffix v of t. The requirements that the partition be proper, that in p have proper parts, and that the suffix and prefix u,v are distinct or. the inequality \(\leq\) be strict amount to the same.

Duality of location and duration adverbials

The interpretation of simple frame adverbials is a pragmatic matter. Does today mean all of today or some of the day? The likely understanding seems sensitive to many things, including event type and background assumptions. Compare for instance:

Were you at school/home today?
Did he play (well) this season?

Knowing that school only takes part of the day, and that people usually spend some of the day at home makes one or the other choice informative. Adding well demotes playing from assertion to presupposition: did he play or not vs. was his game good or not. This is a question about season’s averages, and one good game does not resolve that. On the other hand, one good game is good for a recored, so He hit a home run last season means he did it sometime during the season. Generalising from these and similar examples, it seems right to say the reference time is a free contextual variable:

e today = e|t in today

Thus logically, a frame adverbial is equivalent to existential quantification (though the intended reference time is often provided by the context, Kuhn 1989:536). I shall argue that there is a more illuminating way capture the equivalence, based on the Boolean duality given by equivalences

e|\in today = around e\in\today = e \\subseteq \today

Vlach (1993:250) claims today must be given a durative interpretation in Max is here today, meaning for the present day, not just an inclusive interpretation, meaning at some time in the present day, because the latter interpretation in his approach to tense would not not imply that Max is here now. The empirical claim seems false to fact. Max is here today does not preclude Max will leave today afternoon nor even But he is out for the moment. The least that must be said is that the event types here and today meet. Any extensions of it are allowed (Declerc 1997:106).

Vlach allows this in the context of Max worked regularly last year, which does not have to mean Max worked regularly for the last year, it can mean just Max worked regularly for a while last year. Vlach ends up inserting an understood durative adverbial for a while in the sentence allowing last year to double as an inclusive adverbial. The adverbial insertion idea is used in Bäuerle (1979:47), Nerbonne

Let us look how the different readings come about here. On the durative reading of Max is here today t equals today, which entails Max stays for the day. However, there are others obtained from aspecual differences of verbs or adverbs. The weaker for a while reading is obtained by leaving the choice of t free. The formula here in 1973 only entails that Max is here for part of the day (he may or may not have arrived in the morning and/or be leaving tonight). Vlach’s worry that this reading might not imply Max is here now is unnecessary, for the present tense here in today guarantees that.

Alternatively, one can apply aspect to here and turn it to a perfective pf here\(\cap\)today. This implies that Max makes one visit here today: he arrives and leaves on the same day. A frequentative (pf here)\(\cap\)today allows Max to come and go freely, all that is implied is that he is here sometime today.

Pace Vlach, I think this is also a possible way to take Max is here today. (Is Max here today? Yes he is, although he is out at the moment.) The weak reading sometime today also comes about through weak complementation: it is not true that Max is not here today can mean Max is here sometime today: \(\sim\)here\(\cap\)today. And if all day is the event type of day length events, then we can single out the stronger reading by sleep\(\cap\)all day\(\cap\)today.

The simplest reading of a closed event Max leaves today is here,\(\sim\)here\(\cap\)today, which implies that there is just one departure today. Max is here today until he leaves and he will not return today. A looser reading is obtained from the perfective of leave pf leave today, i.e. \(\sim\)leave,\(\sim\)leave,\(\sim\)leave\(\cap\)today, which says that Max leaves once today (he may return but he won’t leave again). Perhaps the most salient reading is obtained by interpolating an implicit reference to a (definite or indefinite) tighter reference time within today: pf (leave(t) today which only says that there is a departure today which is in some sense unique; say, the only one within some salient time t today, or, taking t to be some other concomitant event type, the only one of a certain kind today. This is Partee's I did not turn off the stove today: I may have turned off the stove several times during the day, but not when we left home. Even further possibilities are opened with iteration leave* today 'leave once or more today', which allows Max to go back and forth as he wishes. Logically, all of pf (leave(t) today, leave* today, and leave in today are equivalent, though the composition is quite different.

Vlach (1981b:77) notes that Max didn't die in 1973 hardly means There was a time in 1973 when Max didn't die. Not surprising, for the intended reading is vacuously true. Where it is not, the reading is conceivable: In 1973, Max didn't attend a meeting. Here too, an occasion t for the negative event (a particular meeting) is construed when it ought to have happened but did not, i.e. the event type is really (\(\sim\)attend(t)\(\cap\)in 1973 which is equivalent to pf (\(\sim\)attend(t)\(\cap\)1973.

Tedeschi (1981) finds that many putative scope ambiguities just are not there: John won’t be in the store tomorrow \(\sim\)(in store) tomorrow is usually taken to deny John will be in the store tomorrow, does not have a weaker reading \(\sim\)(in store) tomorrow. John will be out of the store sometime tomorrow. Here too, scope vanishes because quantification is contextually narrowed down to unique reference. Compare Pearl didn’t sleep at the kindergarten today/ John slept at school today. The news is different in each case: in the former, Pearl did not sleep when she was supposed to, in the latter, John slept when he was supposed not to.

Gabbay and Moravcsik (1980:81) find He was working on his paper yesterday ambiguous (‘a period of paper writing can be located within the period of yesterday’ vs. ‘yesterday was a part of the ongoing activity of the work on the paper’) depending whether yesterday is a referential sentential adverbial or a durational adverbial one. I locate the ambiguity in an aspecual difference between (prog work)\(\cap\)yesterday vs. (pf prog work)\(\cap\)yesterday. In the first case, the bounds of working are yesterday, in the latter, they are inside it. The first one makes yesterday durative (universal) because the work extends throughout yesterday, the second one referential (existential) because it does not. In the adverbial case, yesterday applies directly to work, in the sentential case, a perfective intervenes.

In some languages, including Portuguese and Bulgarian, many adverbials are vague about locative vs. durative reading, and it is the aspect that decides which one is in question. Does this mean that Portuguese adverbials are ambiguous? It should not. Applying the same thinking as we did explaining existential and universal readings of the perfect, the obvious solution is that loose fit (location) and tight fit (duration) are dually related (like existential and universal quantifiers). What is loose fit of one

\footnote{Harkness (1987:89) criticises Fabricius-Hansen’s (1984:63) suggestion that today can refer to only a part of today for ‘suggesting that the referring expression refers to less than what it refers to’. This criticism fails to distinguish between the noun today and the adverbial in today.}
event type becomes tight fit of a dually related event type. This is confirmed by the observation that the negation of a loose adverbial is a tight one: the negation of e in t is not e for t.\textsuperscript{124}

I did not eat for/in a week

\[(t\ \text{in week} \rightarrow \neg\text{eat}) \iff \neg(t\ \text{in week}\land\text{eat})\]

The result that a duration adverbial is the dual of a location adverbial is interesting considering that some languages use the same adverbial but different aspect to express duration (cf. Portuguese and Bulgarian below). \textit{From t to u} is a tight adverbial in English, \textit{between t and u} is its dual and loose (Mittwoch 1988:208). Mittwoch (1988:248) in fact notes that in the progressive (Leech 1969:150), the difference between the two is hardly perceptible:

I was playing piano from ten to eleven o’clock / between ten and eleven o’clock.

In Portuguese \textit{de 10 a 11 horas} can translate either, depending on aspect. Smith (1991:69) reports that neither Chinese nor Navajo has a distinction corresponding to \textit{for} and \textit{in} adverbials. Thus progressive (truth in a time) and perfective (truth for a time) are dual (Humberstone 1979, van Benthem 1981:226).

Given the impartiality of my approach vis-à-vis verbs and adverbs, the ambiguity (or vagueness) can thus be placed in the adverbial or in the verb (or both). \textit{Yesterday all of yesterday} and \textit{in yesterday some of yesterday} are dual, as are the two senses of \textit{be in Boston} (\textit{Boston all the time} vs. \textit{<Boston< some time}). To be in Boston sometime in all of yesterday is just the same as to be in Boston all of the time for some of yesterday. Thus there are alternative ways of picking apart \textit{He was in Boston yesterday}: the aspect can go on the verb or on the adverbial. Often it is more reasonable to attribute aspect to the verb, because the reading is more predictable from the verb. In other cases, it makes sense to assign lexical aspect types or unmarked aspect transitions like \textit{in} to particular adverbials or classes of them.

Summing up, the interplay of time adverbials with event types and tenses is very straightforward in the present approach. Aspects, tenses and adverbials are all objects of the same type, represented and combined with the same Boolean and regular operators. There are no syntactic restrictions as to the combinatory of different adverbials and tenses. In particular, adverbials and tenses are treated as independently denoting expressions, not syncategorematically (Dowty 1982). Any restrictions reduce to logical constraints. There is one basic relation of match between events and adverbials (at or \(\cap\)). Distinctions between location and measure adverbials, \textit{in} or \textit{for}, follow from aspectual properties of the event types and adverbials being combined. This seems an improvement to Vlach’s suggestion (1993:243ff) to postulate two types of adverbial fit which just happen to correlate with the open/closed distinction. It also gets rid of the distinction between proper inclusion and simultaneity in Declerck (1997).

### Loose or tight?

The feeling remains that there is a tendency to understand an open event located in a span of time to fit it tightly inside a time but loosely around it, while a closed event fits loosely inside a time but tightly around it.

A neat way to capture this preference that allows for counterexamples is to move from absolute Booleans to priorities. Define an open event type \(a\) like \textit{be} by the equation \(a = a^\omega\)? which says \(a\) as long as possible. Then for instance

Yesterday I was at home in yesterday \(\cap\) home\(^\omega\)?

has as its \textit{preferred} interpretation that I was home all day (that is the longest event compatible with the above event type), but it is \textit{compatible} with narrower specifications, such as

Yesterday I was at home for an hour in yesterday \(\cap\) hour \(\cap\) home\(^\omega\)?

Dually, a closed event type \(b\) like \textit{leave} will be defined by the opposite preference that it takes as little time as possible. Then for instance

I left home at noon noon \(\cap\) ~home\(^\omega\).home\(^\omega\)?

\textsuperscript{124}The topological intuition that an open event can fit a time tightly while a closed one leaves a gap seems based on the fact that the difference of properly nested closed sets is open (a gap) while that of an open set and its closure is a nowhere dense set (the boundary).
has as its preferred interpretation that I left home quickly at noon sharp, but allows for slower departures and looser times too:

The birds leave home in the fall. **pl bird ∩ pl leave ∩ in fall**

The plural event type **pl leave** may be an accomplishment though **leave** is a change.

**Bounding adverbials**

**Bounding adverbials**, including **bounding duration adverbials in t** where **t** is a measure expression, and **bounding location adverbials by t** where **t** is a location adverbial, are a special case of location adverbials. There is no factual difference between **Can you do it in an hour?** **Can you do it by noon?** and **Can you do it this morning?** said at eleven. But bounding adverbials are tight and produce closed event types when **t** is interpreted as a least bound: **in t in t** is not of type **in t** but of type **in 2t**. The bounding location adverbial **by t** can be defined as **x:x≤t**, so **e by t** reduces to **e≤t**, i.e. **by t** gives a later bound of the occurrence of **e** (usually, but not always, an earliest later bound). **Quickly, immediately and instantly** and are bounding adverbials (in no time, in a short time, in an instant).

As the formula indicates, the entire event is included in the time bound. **I will build a house in a year** is a promise to build all of it within the year. By the same token, **I will have built a house in a year** only means the event of **having** built it is included in a year (I may have started earlier).

Open events appear within bounding adverbials only marginally. Bounding adverbials are often used as a test for closure in aspect literature. Downward entailing event types are hard to bound tightly from above, for if the event holds in **t**, it holds in a prefix of **t**.

**John ran in an hour. run in hour**

This problem is cured with additions which denote initial or maximal subevents.

**John was running in an hour. in run in hour**
**John ran a mile in an hour. mile in hour**

A simple open event type **a in t** amounts by default to inception because an open event has occurred as soon as it has started, so it is in effect timed by its inception (Krifka 1998:217). **He was up and dressed in two minutes** is practically tantamount with **He got up and dressed in two minutes**. This is a consequence rather than the rule, however. Compare for instance **Everyone was got up and dressed in two minutes** - maybe some were up and dressed to begin with, so **got** is not in general equivalent with **was** here. The unproblematic opposite scoping (**b in t**)” is exemplified by **fr Il reparait toujours sa voiture en trois heures**'he always repaired (impf) his car in three hours' (Johanson 1998).

By the asymmetry of time, unanchored bounding adverbials appear to set later bounds rather than earlier bounds. The start time of an ongoing event cannot be varied, its end can. Bounding measure adverbials in **t** are often anchored from the left: **in two minutes** means in two minutes from now/then, i.e. in the next/following two minutes. They need not always be: **can you put up a tent in two minutes** does not have to mean in two minutes from now. They have to be when the event type is simple (has no minimum duration). Otherwise, **Everyone was up in two minutes** would be rather irrelevant, for anyone is up in **no time**, counting from when one gets up. An anchored bounding adverbial in **t** from **u** is in effect a (tight) frame adverbial. Earlier bounds are set by anchored past adverbials like **since** or **fr depuis**.

The intuitive contrast between **by** and **before** is ‘no later than’ ≤ against ‘before’ <. The difference is clear when the bound has an extent, and is minimised when it is atomary. There is a difference if an application has to be in before **Friday** or by **Friday**: the latter may include some or all of Friday.

While duration adverbials are downward persistent, bounding adverbials upward persistent, meaning **he ran for 10 minutes** entails **he ran for 5 minutes**, while **he ran home in 5 minutes** entails **he ran home in 10 minutes** (Herweg 1991). This is why **He ran home in at least/at most ten minutes** are odd.

**Since and until**

The tight bounding connectives **since e** and **until e** are interesting both logically and typologically. **Since** and **until** are prime specimens of topological temporal connectives. In the current symbolism, **since e** denotes a time **e < starting from e up to reference time. Since** is a mirror image of **until: until e** denotes ≤**e**. Essentially, these connectives are thus denotational variants of concatenation: **p since q** is just **q > p** and **p until q** is **p < q**.

This may appear too feeble for practical purposes. Most times, we draw more inferences than supported by the definition so far. First, there is aspect: the main clause of **since** and **until** is open, the subordinate
clause is closed. Since and until are etymologically source and goal adverbs, respectively. The main event goes on ever since, or all the way from, and until, or all the way to, the subordinate event. Equivalently, there is an implicature that \( p \) ends at the nearest token of the boundary event \( q \). The sentence on the left practically implies the other two.

\[
\begin{align*}
\text{I slept until I was rested.} & \quad \text{I was not rested while I slept.} & \quad \text{I did not sleep once I was rested.} \\
\text{\( \neg q \)} & \quad \text{\( p \land \neg q \)} & \quad \text{\( p \land \neg q \)}
\end{align*}
\]

It is arguable that the latter implicature is defeasible:

\[
\text{Did they wait until you arrived? Yes, they waited until everyone was there.}
\]

Obviously, it is possible for \( p \) to go on after \( q \) becomes true. Or consider The show ain’t over until the fat lady sings. The song is also part of the show.

The first implication is harder to cancel, for until does not make a semantic difference without it. The concatenation of two compatible open events is symmetric: \( pq \) equals \( qp \) equals \( p\neg q \) when \( p \) and \( q \) are open and nonexclusive. This consideration already halfway implies the aspect constraint: for an asymmetric tight concatenation \( pq \), one of \( p \) and \( q \) must be open, the other closed.

The interdefinability between while not and until is assumed in iteration constructs of many computer languages. The equivalence requires seriality of time, i.e. the principle that always \( q \) entails sometime \( q \). In linear temporal logic, \( p \) while not \( q \) (known as \( p \) release \( q \) ) is entailed by \( p \) until \( q \) but the converse implication only gives eventually \( q \).

\[
\text{\( p \) while not \( q \) (for open \( p \)) equals \( p \) as long as not \( q \). Some languages use the same word for \( while \) and until and use aspect to decide the sense: Russian \( pokha zhivet/umeret \) ‘while he lives/until he dies’, Bulgarian \( dokato pribirat/priberat \) rekoltata.'while/until the harvest is collected'. Compare also \( p \) as soon as \( q \), \( p \) right after \( q \).
\]

Causation can be spelled out using a causal until: I hammered the metal flat means I hammered the metal until it was flat. This is the measuring out interpretation of causation discussed in the chapter on nominals. A causal since dually spells out achievements: I slammed the door shut means the door is shut since I slammed it.

Another equivalence holds between \( p \) until \( q \) and (not \( q \)) (not before) \( p \), i.e. between \( pq \) and \( q \leq \neg p \). The latter says that \( p \) does not end before \( q \) begins. Recall also that not (\( p \) until \( q \)) equals if ever \( q \) then (not \( p \)) before \( q \). Here ever \( q \) is \( \neg q \), which is the same as \( \neg q \), or \( \text{I until } q \). This is the sense in which before \( f \) and until \( f \) are dual: before \( f \) equals not (not \( e \) until \( f \)).

Lewis (1967) defines a stronger version of until which is one sort of dual of the present one (Kamp 1968), defined by \( q \leq \neg p \) or \( p(q\neg q) \). This operator does not suffice to cover all event types on real time. One difference is that Kamp’s until can characterise discreteness as the truth of the event type \( \varnothing \) until \( 1 \). An example of this in natural language is when the granularity of events is discrete. We have no time until tomorrow, nothing happens until tomorrow can be true for a granularity where nights are not counted, although there is always time, something always happens are true in general.

Since and until can define unary tenses. Sometime in the future, eventually \( p \) or now \( \langle p \) equals now.(\( \langle p \) until \( p \), always in the future, henceforth \( p \) or now, \( p\neg q \) future equals now.(\( p \) until \( \varnothing \). Conversely, \( p \) until \( q \) is definable given unary tenses and variables (Marx 2001:692):

\[
\text{\( q\land t \text{ in future} \land \text{future}f\land(t \text{ in future} \rightarrow p) \)}
\]

I sleep until morning means morning is some time in the future and for all the future I will sleep if that time is still in the future.

Tight or loose?

Since is a tight (first order universal) bounding adverbial. Consider the question

\[
\text{Have you slept (ever/ at all) since yesterday?}
\]

This seems ambiguous. Mittwoch (1988:207, referring to OED and Leech 1969:132ff) claims that since is ambiguous between existential and universal senses, where the existential since \( t \) means after \( t \), and the universal one means from \( t \) on/as long as \( t \). The suspicious part of the ambiguity claim is that the senses of since pair up regularly with the existential and universal senses of the perfect and the open/closed distinction. The universal (durative main clause) since answers the question how long, the
existential universal ones *how many times*. Neither can answer *when*. The contrast is clearly felt by adding *at all/ever*. Heinämäki (1974:128) notes that apparent existential cases actually have a quantified noun phrase or adverb (explicitly or implicitly) in the main clause that tightens the match. If there is no such thing in the main clause, the sentence looks odd:

I have met an Eskimo since I came here.

Heinämäki notes that the sentence becomes more natural in the following context:

I have met an Eskimo since I came here, I wonder what other interesting people I’ll meet.

Why should this make a difference? Obviously because the continuation suggests that set of all interesting people I have met since I came here already includes an Eskimo. It thus supports the following tight paraphrase of the sentence:

I have already met an Eskimo since I came here.

The duality of readings is not restricted to English; Finnish *saakka* is also acceptable for both readings of

fi Hän on valehdellut (vain kerran/aina) siitä saakka kun hän oli lapsi. ‘He has lied (just once/ever) since he was a child.’

*(Just) once* is again a unique quantifier context in which positive and negative polarity items are known to come together. Due to the frequency adverbial, both readings have very straightforward representations without postulating two senses to *since*. The difference follows from aspect alone. *He has lied ever since childhood* goes to *child.lie.now* and *He has lied once since childhood* to *child.lie.once.now*. The former says that continuous (iterated) lying extends from some time in childhood, though hardly since birth. The former says that all the time from some time in childhood contains precisely one lie.

Mittwoch claims that

Sam has been in Boston at least since yesterday
can only be universal, so that *at least since yesterday* means *yesterday or earlier, or yesterday at the latest*. Another type of sentence which she only assigns a universal reading of *since* is the perfect progressive

John has been running since 7.

Again, the availability of an apparent existential reading goes with aspect. Compare

John has been running once since 7.

Has John been working on his book (at all) since he got the job?

In the former, *once* turns the sentence into an event. In the latter, the question frames the sentence as a positive existential, the negation of John has *not been working on his book since he got the job* which is a universal negative. The denial would not entail that he has been steadily at it, only that he has not relinquished the project. Mittwoch feels *John has been running for 2 hours since 7* is ill-formed. I find it unusual, but not excluded. A rather good reading is *John has been running for a total of 2 hours since 7*. Another possibility that John has been repeating 2 hour rounds since 7.

Bennett and Partee (1972) feel *John has been building a boat since yesterday* can have a reading where it is true at the present moment if there exists a time since yesterday where *John is building a boat* is true. One use is affirmation (stress on *has*), denying *John has not been building a boat since yesterday*, through the duality of tight and loose aspect ¬*build* versus ¬~*build* equals <build>.

A key feature of this analysis is that both the universal and the apparent existential readings involve tight match. The lesson from this is that when several distinctions regularly covary, they may be the same distinction. Here, the apparent existential/universal ambiguity of *since* pairs up with the apparent existential/universal ambiguity of perfect and finally with open/closed aspect, because they all are just views on the same aspect distinction.

---

125Heinämäki (1984:129) suggests *ever since* requires a durative main clause. It may be enough to imply one: *I have met only one eskimo ever since I came here* seems passable, entailing *I have not met more than one eskimo.*
**Bounds and duality**

*Since* and *until* are the tight duals of the loose adverbials *after* and *before/by*. The following negative sentences mean about the same, but the scope of the negation is different: *not-before* means *until-not* and *since-not* equals *not-after*.

\[
\neg(\text{here}<\text{war}) \text{ vs. } \neg(\text{war}<\text{here}) \text{ vs. } \text{war}.\neg\text{here}
\]

German *bis* 'until/by' is dually vague (Johanson 1998):

\[
\text{de Ich wollte das Problem/Probleme bis zwölf Uhr lösen 'I wanted to solve the problem/problems by/until 12 o'clock.}
\]

The bounds of the *since* event vary according to scoping:

- Sam has been in Boston ever since Tuesday (when he was there).
- Sam has not been in Boston since Tuesday (when he was there).

With *ever*, there is a tendency to include Tuesday, with *not* to exclude it. This is a predictable consequence of rounding up or down from some time Tuesday. The implicatures are defeasible, by varying granularity (say, counting working days). Compare also

\[
\text{Since Tuesday, Sam hasn’t been in Boston (has been elsewhere).}
\]

The sentence seems to say that *from* Tuesday *on*, Sam has been elsewhere. Emphasis on *not* seems to deny the presence of Sam in Boston at any time *after* Tuesday. (Again, the preferences are defeasible.) The first one is a universal *since* applied to the complement state, the second a contradictory of *after*, the loose dual of *since*.

As Heinämäki (1997:134.) notes, a closed *since* clause is in the simple past and an open one in the perfect. The time of the main clause is the result state of the *since* event in both cases.

- He has lied once since he went/has gone to school.
- He has not lied since he went/has gone to school.
- He has been honest since he went/has gone to school.

If he is *still* at school, the only past time to count from is the time he started. If he has finished, both starting and finishing are viable options. The intended reading can be sorted out by adding *first/last* (Jespersen 1949:§5.9.1). For acquisitions, both tenses are possible with the same effect (cf. Jespersen 1949:§5.8); even present tense may appear. In the latter case, *since* is interchangeable with *as long as*.

\[
\text{Her husband has been in love with her ever since he knew her.}
\]

\[
\text{I have known this, night and day, since I have known you in your home.}
\]

\[
\text{I have had these impulses since I can remember.}
\]

Intuitions about bounds thus vary predictably with tense and aspect of the bounding and the bounded event. There is an analogous phenomenon of *not before* implying *only after* when an event is contracted to a point (treated as atomary). Which end of an event counts depends on whether the event is open or closed on the level of resolution being operated on. (Cf. the section on order.) The bounds of the *until/since* clauses vary predictably with examples like *He had lived there since/until he was young/old* (Steube 1988:202). The following sentence is multiply ambiguous, allowing it to say different things:

\[
\text{I have not been happier since I was married.}
\]

\[
\text{'It is not true that ever since my wedding, I have been happier than before'}
\]

\[
\neg(\text{married}.\neg(\text{married} \land \text{happier}).\text{now})
\]

\[
\text{I am at least as happy now as ever since my wedding'}
\]

\[
\neg(\text{married}.\neg(\text{married} \land \neg\text{happier}).\text{now})
\]

\[
\text{I am at least as happy now than ever since my marriage'}.
\]

\[
\neg(\text{married}.\neg(\text{married} \land \neg\text{happier}).\text{now})
\]

The absence of a fourth reading denying 'I have been happier ever since my divorce' is a consequence of the the perfective paradox (see section on asymmetry of time).
**Tenses**

*Sleep since yesterday* denotes the course of events *yesterday’s sleep*. What about the tense? By my analysis, the event types described in the main and subordinate clauses are adjacent and the main clause event borders on the present. This allows us to rule out a proper past from the main clause of a since sentence (Bennett/Partee 1972):

> John walked since yesterday.

Trying the present tense for fit, we get (*yesterday’s sleep* ∩ *now*, which forces the present tense to extend to the past - something that English currently only allows for bound presents (see section on sequence of tense). The likely reason for the constraint, and the best fit for English *since*, is the present perfect, which unpacks to *yesterday’s sleep now*). Note how *since* allows *yesterday* co-occur with the present perfect by removing it from the scope of the present tense, while the perfect frees the sleep to extend to the past.

Since *e* entails *e* is past relative to a *now*. *Tomorrow they will have been up since sunrise* does not belie this. Compare

> Asok works here from January till December. \[Jan ∩ Dec ∩ work ∩ now\]

> Asok works here since January till December. \[Jan ∩ now ∩ work ∩ Dec\]

The first sentence is unproblematic: all event types have a nonempty meet of one year. The second sentence is not, for *since January* denotes a near past, which calls for perfect in English.

It seems that the simple present is tolerated with *since* in present-day English in a few interesting cases where a present tense sentence makes implicit reference to an extended now (Harkness 1985, 1987, Mittwoch 1988:219, Hamann 1989). For instance *I feel better* below equals *My condition has improved*.

> It is 2 years since he died.  
> I feel better since the plaster came off.  
> Since last night he cannot move his fingers properly.  
> I am walking to work since my car broke down.  
> I am a very light sleeper since I have travelled in the Heavens, said Ransom. pt ‘Tenho o sono muito leve desde que viajei nos céus, disse Ransom.’ (C.S.Lewis)

Beyond that, the perfect is used in the main clause and past tenses in the *since* clause. Kamp (1968) apparently only considers present perfect *since* sentences. But it appears in other tenses as well (Heinämäki 1974:127, Hamann 1989:151).

> He had been there once since he left London.  
> He will have been there once since he left London.

**Asymmetries**

Heinämäki (1974) wonders why *until* is not a negative polarity item although *before* is: *He stopped before everyone was bored* does not entail *everyone was bored*, but *He went on until everyone was bored* does. This looks like evidence for branching time. In branching time an event need not be foregone until it happens, but once it does it cannot be undone. Picture the following diagram:

---

126 Heinämäki (1974:130) only considers this type of simple tensed main clauses. She notes that they can be transposed to other tenses: *Next month it will be 2 years since he died.*

127 This sort of example (Leech 1971:45) is an obvious locus of neutralisation between temporal and explanation senses of *since*. The explanatory *since* imposes no tense constraints but only occurs as the outermost operator of a sentence (Heinämäki 1974:139-140). For Hirtle (1975:47), ‘the hesitation to use ever suggests that *since* does not have its full temporal value.’ Mittwoch (1988:247) considers this type unacceptable.
The background assumption is that if you go on long enough everyone eventually gets bored, i.e. blab $\leftrightarrow$ not bored. Until that, you can prevent it any time by stopping, but once you reach the saturation point, boredom is there. Since until is tight, this point is actually reached and boredom follows. As Heinämäki (1974:145) observes, *He went on until everyone was bored* is the contradictory of *He stopped before everyone was bored*. As the picture also shows, this means *He stopped before everyone would have been bored*. The past tense takes us back to the root, where the alternative future was still an option.

As Heinämäki (1974:122) observes, a until $b$ does not entail $\neg a$. One can blab on even after everyone is bored. $b$ is a lower bound, but not necessarily an upper bound. However, Gricean maxims usually support the stronger implicature. The above examples also show that $b$ is not always presupposed: it is not when $b$ results from $a$ (Heinämäki 1974:125).

There are cases where until is counterfactual (the until clause represents someone’s plan which is not necessarily realised):

They got/kept him locked up until the rebels would return the hostages.
I told the gatekeeper that we wanted to stay in the park until he shut/had shut the gates (Allen 1960:143).

Heinämäki (1974:140-141) points out apparent asymmetries between since and until. She suggests until only takes durative main clauses. I am not sure about this. Until can measure the result state of a closed resultative event, as it does in the above example. Another possibility is that the main clause event is a unique one. The following seem all right:

She has seen him only once since he was released from prison
She will see him only once until he is released from prison.

Another putative asymmetry is that since clauses have to denote (indexical) past time, while there is no converse restriction of until clauses to the future. This too is doubtful: a since clause can denote a relative past time to the extent its past tense can. The following seems acceptable as an argument against releasing someone from prison:

When he is caught again, it will turn out he has gone on stealing ever since he was released.

Turn out provides here a sufficient context to bind the now of the simple past tense.

**Perfect vs. present**

Languages without an open present perfect make do with the present tense. To compensate, many have near past adverbs which double as bounding and duration adverbs meaning since t or in/for the last t: fr depuis, es desde, it da, de seit (Bertinetto/Delfitto 1998):

| fr | Je suis ici depuis deux heures. here $\cap$ 2h $\cap$ now $\cap$ or here $\cap$ 2h $<\cap$ now $\cap$ now |
| en | I have been here for two hours/since two o’clock. (here $\cap$ 2h) $r$ now or (here $\cap$ 2h $<\cap$ r) now |

English has a present perfect with a duration adverb, French an extended present with a past bounding/duration adverb. The devices produce equivalent formulas. The French translated verbatim says ‘I am here since two hours’. Similarly in

128Heinämäki (1974, section 6.4) is a good discussion of the implicatures of temporal clauses.
Maria dipingeva la parete da mezzogiorno/da due hore quando ritornai. ‘Mary had been painting (impf) the wall since noon/for two hours when I returned (pf).’ Bertinetto/Delfitto (1998)

Maria pintava la pared desde el mediodía/desde dos horas cuando volví. ‘Mary had been painting (impf) the wall since noon/for two hours when I returned (pf).’

In French, present perfect is also admissible when the sentence is negative.

Il n’est pas/n’a pas été ici depuis 2 heures. ‘He has not been here since 2 o’clock/for 2 hours.’

Je ne l’ai pas vu depuis 2 heures. ‘I haven’t seen him since 2 o’clock/for 2 hours.’

The perfective perfect yields a closed near past of the acquisition voir ‘see/spot’, the negation turns the event to an open near past, which matches the near past depuis 2 heures.

Perfect is also possible when the event type is half closed, in which case depuis measures the result state. On irresultative event types, passé composé denotes a perfective past event, which excludes depuis (Franckel 1989).

Max a reparé la voiture depuis deux jours. ‘Max has fixed the car two days ago (the car has been fixed for two days)’

Max s’est reposé depuis deux jours. ‘Max has rested a while for two days.’

Additions which turn event types into these types save the day (Marque-Pucheu 1998). Note the duality of English in/for in the translation.

Geler ‘freeze’ is a comparative change, i.e. a process accomplishment, so it needs a resultative perfect.

Portuguese desde too accepts both Perfeito and Presente in the temporal clause with a predictable difference in meaning:

Desde que o João estive/está doente que não come bem. ‘Since he was/has been (pf/pres) ill John hasn’t been eating (pres) properly.’

In Italian too, the present perfect with da measures the length of the result state:

Maria ha dipinto la parete da due hore. ‘Mary has painted the wall two hours ago.’

To say in French We came here two days ago one thus cannot say Nous avons venu ici depuis deux jours. Instead, a dual of depuis, il y a ‘t ago’ appears: Nous avons venu ici il y a deux jours.

fr Nous vivons ici il y a dix ans. Il y a dix ans que nous vivions ici. ‘We’ve lived (pres) here for ten years (lit. there are ten years that we live here).’

fr Nous avons venu ici il y a dix ans. Il y a dix ans que nous avons venu ici. ‘We came (pc) here ten years ago (lit. there are ten years that we have come here).’

pt Mudámo-nos aqui há dez anos. Há dez anos que mudámo-nos aqui. ‘We moved (pf) here ten years ago.’

pt Vivemos aqui há dez anos. Há dez anos que vivemos aqui. ‘We have lived (pres) here for ten years.’
Here the temporal adverbial *il y a/hâ t que t.now* 'there is t such that' is originally a main clause and the main clause tense originally a bound present (perfect).

**Temporal conjunctions**

The following table details the definitions of a number of location and duration adverbials including ones that can be used to form adverbial clauses, and mentions associated aspectual constraints (cf. Bennett/Partee 1972, Heinämäki 1974, Bertinetto/Delfitto 1998).

<table>
<thead>
<tr>
<th>connective</th>
<th>formula</th>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>e at f</td>
<td>e∩f</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b in f</td>
<td>&lt;b∩f</td>
<td>b bounded, f extended</td>
<td>closed</td>
</tr>
<tr>
<td>e during f</td>
<td>&lt;e∩f</td>
<td>f extended</td>
<td></td>
</tr>
<tr>
<td>e while f</td>
<td>&lt;e∩f</td>
<td>f extended, bounded toward future</td>
<td></td>
</tr>
<tr>
<td>e as f</td>
<td>e∩f</td>
<td>e and f in same situation</td>
<td></td>
</tr>
<tr>
<td>a for f</td>
<td>a∩f</td>
<td>a open, f extended</td>
<td>closed</td>
</tr>
<tr>
<td>a throughout f</td>
<td>a∩f</td>
<td>a open, f extended</td>
<td></td>
</tr>
<tr>
<td>a all the while f</td>
<td>a∩f</td>
<td>a open, f open</td>
<td>open</td>
</tr>
<tr>
<td>e as long as a</td>
<td>e∩a</td>
<td>a open, bounded toward future</td>
<td></td>
</tr>
<tr>
<td>e by f</td>
<td>e≤f</td>
<td>e bounded toward future</td>
<td>closed</td>
</tr>
<tr>
<td>e before b</td>
<td>e∩f</td>
<td>f bounded toward past</td>
<td></td>
</tr>
<tr>
<td>e after f</td>
<td>f&lt;e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e once f</td>
<td>f&lt;e</td>
<td>e,f bounded toward past</td>
<td></td>
</tr>
<tr>
<td>e as soon as f</td>
<td>e∩f</td>
<td>e,f bounded toward past</td>
<td></td>
</tr>
<tr>
<td>a since b</td>
<td>b`a</td>
<td>a open , b closed toward future</td>
<td>open</td>
</tr>
<tr>
<td>a from b on</td>
<td>b`a</td>
<td>a open , b closed toward future</td>
<td>open</td>
</tr>
<tr>
<td>a until b</td>
<td>a`b</td>
<td>b closed toward past</td>
<td>closed</td>
</tr>
</tbody>
</table>

**Table 40**

Generalisations: Tight connectives entail one of the connected events is open, the other closed. Later bounds entail that the main event is (half) closed, earlier bounds do not. No surprises here.

These claims can be tested with the following frame:

He slept soundly/fell asleep/took a nap P the concert (lasted/began/ended).

*During* is aspectually vague between a loose and tight adverbial. If *during* were a tight adverbial, *He slept during the concert* would entail *He slept through the concert* rather than *He took a nap at the concert.* The manner adverbial seems to encourage a tight reading, probably because it changes focus from the mere fact of sleeping to the quality of the sleep. If it is shocking that he slept at all a loose reading suffices to make the news. With the manner adverbial, the time of the sleep is known or irrelevant. At any rate, *during* is not a duration adverbial: *He took a nap as long as/while the concert lasted* the adverbial acts as a bounding adverbial before it ended.

*The concert lasted as long as he was asleep* has an innocent compositional reading. In *He took a nap as long as/while the concert lasted* the adverbial acts as a bounding adverbial before it ended.

*Before/after* differ from *until/as soon as* in that the former allow loose fit (relate closed events) whereas the latter entail tight fit. More on them below.

---

129English seems to have come the same route: *He died, it is ten years ago(ne) since* (Fryd 1998:40).
As soon as or future once is interchangeable with when next, whose mirror image is when last. Iteration of these operators is one way to define metric tenses relative to a periodic series of clock (or calendar) events: tomorrow equals next day (Prior 1967:106-112, Lewis 1973:110).

The table explains the observation in Bertinetto/Delfitto (1998) that languages with a Romance style grammatical aspect (main clause aspect indicates the output event type) use perfective in the main clause of an until clause and imperfective in a main clause modified by since, while languages with a Slavic style lexical aspect (main clause aspect indicates the input event type) use imperfective in both:

\[\text{it } \text{Maria ballava da mezzogiorno. 'Mary had been dancing (ipf) since midday.'}\]
\[\text{it } \text{Maria ballò fino a mezzanotte. 'Mary danced (pf) until midnight.'}\]

**Adverbials of frequency**

Frequency adverbials count serial events. Iteration alone is impartial about the open-closed distinction; there is both bounded (finite) and unbounded (arbitrary) iteration (Johanson 1998, Hedin 1998). Frequency adverbials must be divided into absolute and relative frequency adverbials (Bennett/Partee 1972:4.2). Absolute frequency (or count) adverbials once, twice, many times output closed event types; relative frequency adverbials output open ones (Klein 1994:209ff). Both input series.

Frequency adverbials input series for the simple reason that open events cannot be usefully counted (their number is not linear to size). As Vlach (1993:240) points out, absolute frequency adverbials output closed event types, not habituals. Portuguese Perfeito is used in Ele esteve duas vezes doente ‘He was has been ill twice’ The reason is easy to see: twice,twice is not twice, but four times.

The regular algebra approach simplifies counting events compared to a point set approach (Bäuerle/Stechow 19??, Tichy 1980). What are count and frequency adverbials like Angelica sneezed three times sneeze\(^3\) includes the event type Angelica sneezed twice sneeze\(^2\), but not conversely, because sneeze as an atomic (singular closed) event type cannot consist of two sneezes in a row.

Relative frequency adverbials like often, seldom, once a day, every now and then are produced compositionally from absolute frequency adverbials and location adverbials. ring twice a day can be defined as a habit (ring ring \(t\) day\(^7\)) or dually as a disposition day \(\rightarrow\) ring,ring. They produce open events: concatenation twice a day, twice a day stays twice a day.\(^{130}\) Slowly and fast are rates and produce dynamic states. Mathematically derivatives, they are continuous, pointwise relative frequency adverbials. Speed is the continuous limit of pace (rate of change per time as scale tends to zero).

**Briefly** is an absolute duration adverbial ‘for a short time’, shortly is its dual, a bounding adverbial ‘in a short time’. Quickly is a relative duration adverbial ‘in for a short time per unit of change’: compare recover briefly ‘for a short time’, shortly ‘in a short time’, quickly ‘in a short time per change’. By this analysis, quickly and fast are inverses; fast is change per time, quickly time per change. A fast train travels far in a given time, a quick train spends little time covering a given distance. Long is a duration adverbial, slowly a relative duration adverbial. Slow speed is paired up with long duration. Both favor imperfective aspect. Note that long is upward persistent, short downward persistent. In a short time is closed, narrow scope long is open. Wide scope for a long time ‘for t and t is long’ is closed.

Cresswell (1977) notes that walk quickly to the station is ambiguous: one can walk quickly but be slow or late if one has short legs or takes a roundabout route. The open event type walk quickly towards the station only has the relative sense, the atomic event type reach the station quickly only the absolute one.

A special case of relative frequency is the time per time adverbial type an hour a time which means for an hour in each time, i.e. (e for t in u).\(^9\)

The adverbial in the average blocks compositional analysis, for once a week in the average no longer implies once a week. Averages are verified over longer periods, so once a week in the average can mean four to five times a month. The logic of statistical concepts like this reflects their mathematics.

Compare He was drunk every Saturday, drunk’\((U)Saturday) He was drunk on Saturdays, drunk’\((p) Saturday) and He used to be drunk on Saturday ipf (drunk’\(f\)Saturday). What is the difference? The first one is strongest, for it leaves no Saturday out. The other two differ in that used to is a remote past, implicating a former habit.

\(^{130}\)Bennett/Partee (1972) claim they also satisfy the subinterval property, i.e. that relative frequency adverbials produce (dynamic) states. I am doubtful.
Aspect and frequency

French Elle levait/leva chaque dimanche à midi ‘She got up every Sunday at noon’ makes a difference between open and closed iteration (absolute and relative frequency) drunk \[(\text{Saturday}) \cup (\text{USaturday})\) and pf (drunk \[(\text{Saturday}) \cup (\text{USaturday})\]). One is a relative frequency claim at a given time, the other an absolute one within the bounds of a given time. There is no formal interaction between the aspect and the adverbs. English can approximate the distinction with on Sundays/each Sunday. The same contrast is found in modern Greek (Hedin 1998).

Romance languages use perfective with absolute frequency adverbs. An imperfective on a frequency adverbial in effect makes it relative:

\[
\text{pt O senhor deixava-a muitas vezes sozinha. (~alone.alone)m+ ‘You left (ipf) her alone often.}
\]

Contrary to common belief, imperfective is not the only option with relative frequency adverbials as in fr Elle sortait souvent ‘she would go out often’. A perfective aspect can apply to the open event type produced by the frequency adverb if a suitable bound is available to close the event type (Molendijk/de Swart 1998).

fr A partir de ce jour-là/pendant des mois, elle sortit souvent. ‘From that day on/for months she went out (pf) often.’ pf (souvent (~out.out)\]{mois).

Russian allows both aspects with absolute frequency adverbials, but with a difference in meaning:

On chital Voini i Mir tri raza ‘he has read War and Peace three times’ ipf read\[^{3}\]

On prochital pismo tri raza ‘he read through the letter three times (then)’ pf read\[^{4}\]

The usual aspect contrast between definite and indefinite past seems to apply. But opposite scoping is also conceivable here:

On pjât' raz perechitâl/perechityval eto pis'mo. ‘He read (pf/ipf) this letter five times.’

A marked imperfective perechetâl pf\[^{+}\] read derived from the perfective perechetâl‘ pf read ‘read through’ can be iterative ‘read through at least once’. The scoping (pf\[^{+}\] read\[^{5}\]) is thus possible, indicating a cycle of reading repeated five times. But the opposite scope option and the associated indefinite past reading (pf read\[^{+}\]) ‘he has read the letter five times at least once’ is not ruled out either. A progressive reading prog (pf read\[^{+}\]) is unlikely, for it would operate on an abstract accomplishment.

The interplay of absolute frequency adverbials with the perfect is straightforward: he has been there twice becomes pf(be),pf(be),now, which unpacks to ~be.be~be.be~be.now.

Rate of change as event type

Typical absolute frequency adverbials are finite iteration operators. e once equals the cycle of e.\[^{131}\], ring twice can be defined as ring,ring, and in general, e n times can be defined as a finite power e\(^n\). The vague frequency adverb repeatedly is a real synonym for iteration e\(^n\), so it is aspectually open.\[^{132}\] Logically, an absolute frequency adverbial n times can be treated as a first order quantifier e\(^n\) applying to a singular event or as a second order quantifier classifying sets of events e\(^n\)[\(\{n\}\)] where n is the event type of n-tuple events. Absolute frequency adverbials produce closed complex event types.

Less typical uses of absolute frequency adverbials allow counting simultaneous tokens of an event type. Here belong cases like break an arm twice at once or insult someone twice in the same breath.

We can extend our treatment to these cases by basing event count on the Boolean sum of events instead of concatenation product: break twice is break+break, or 2break. This sums different tokens, not the same type (otherwise the sum would be nil).

The aspect of relative frequency adverbials is less obvious. Like habituals, they seem curiously ambivalent. A relative frequency assertion like He eats twice a day seems, on the one hand, require a longish window of time to ascertain an average frequency. But once defined, the relative frequency assertion seems to apply to any or all of the time within the window, yet nowhere in particular within it.

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\[^{131}\] Though logically equivalent, die and die once denote different things. Die once is a pulse of dying: it is closed by not dying on both sides. you only die (nothing else happens) is not equivalent you only die once (not twice). He died reports a death at a definite time, He died once is a truism (with focus on once) or indefinite (with focus on died). These distinctions follow:

\[^{132}\] This explains the contrast found by Bennett and Partee (1972) between the ambiguity of John slept repeatedly for half an hour (pf\[^{+}\] sleep\[^{181}\]h) or pf\[^{+}\] (sleep\[^{181}\]h) and the unambiguity of John slept three times for half an hour. (sleep\[^{181}\]h\(^3\)). Repeatedly is open, three times forms a closure.
One can say he eats twice a day (right now, as we speak), but cannot very well make sense of look, there he eats (is eating) twice a day pointing to a scene or picture of someone (eating or not eating). Eating twice a day seems a state, but an abstract one, with a temporal profile not visible in a still image.

As it happens, the TMAD calculus allows making these intuitions precise. The starting point of the analysis is the event type \( \text{ring twice in an hour} \). This can be read as is, as a complex event type \( \text{ring}^2 \text{in 1h} \). By definition, this equals \( \text{ring}^2 \otimes \text{in 1h} \) which entails that the event type \( \text{1h} \) includes (subsumes) a subtype (token) event type \( \text{ring}^2 \text{t/in 1h} \). By definition of quotient, it follows that the quotient event type \( \text{ring}^2 \text{t/in 1h} \) denotes the null event type \( \emptyset \). (Recall that the null event type \( \emptyset \) is the concatenation identity.) This quotient event type is a state by my definitions, and it holds everywhere inside the original event type \( \text{ring}^2 \text{in 1h} \).

Consider more carefully how one counts events. Given an event type \( t \), we want to know how often event type \( e \) occurs in \( t \). The problem with counting arbitrary (open) event types is that the number of occurrences of \( e \) may be arbitrary (open). Topology tells that in a compact space, a bounded closed cover of a set has a coarsest finite subcover. The number (cardinality) of the cover is unique, although the cover need not be. There is a fixed finite number of changes of sign from \( e \) to \( -e \) separating monotone states of change in a bounded region. One cannot live twice without dying meanwhile. There is any number of ways to split between night and day, but there is a unique number of days. The number of waves at any given time is finite and fixed. So is winding number, or the number of closed orbits around a point. In general, in a closed bounded compact continuous nonmonotone curve, there is a finite number of changes of state between as many states of change. Counting the states equals counting the changes.

To count event type \( e \) in \( t \), form the closure \( \text{pf} \ e = b \) and prove the event type \( \text{nb in t for some n} \). To obtain the event type of the relative frequency or rate of change of \( e \) in \( t \), choose a partition of \( t \) in some unit \( u \) so that \( t = mu \) and consider the event type \( \text{nb in mu} \). The relative frequency is then the quotient state (null event type) \( \text{nb/in mu} \) which equals the event types \( n \text{(b/in t)}, n(h/in mu), \) and \( n/m \text{(b/in u)} \). This quotient event type in fact represents the quotient or equivalence class of all events going at this rate.

Generalising further, consider three event types \( e,f,g \) and times \( t,u,v \) related by \( t = uv \), i.e. \( v = u\underline{t} \), or equivalently, \( t = u+v \) and \( v = tu \), and analogously, \( e \at t, f \at u, g \at v \). We have the following derivation:

\[
\begin{align*}
e &\at t \\
f+g &\at u+v \\
f &\at u , \ g &\at v \\
e|f &\at t\underline{tu} \\
(e|f)/ &\ (u\underline{t})
\end{align*}
\]

What happens here is that the event \( e \) is considered as the concatenation of events \( f \) and \( g \) at the concatenation of times \( u \) and \( v \). This is also the concatenation of events \( f \at u, g \at v \). On the other hand, the event \( g \at v \) can be represented as the difference \( (f \at u) \setminus (e \at t) \) of the total event \( e \at t \) and its beginning \( f \at u \). This quotient event type can also be represented as the event type \( \text{fe at t/u} \). Taking finally the quotient of this event type by the time \( t\underline{u} \) gives us the rate of change

\[
(e|f)/ \ (u\underline{t})
\]

This event type constitutes the TMAD calculus representation of a differential. When this rate reaches a definite value at the limit as \( u \) reaches \( t \), we can talk about the rate \( de/dt \) of \( e \) at the point \( t\underline{t} \).

The tools developed so far allow us to formalise the following valid inference about event types:

\[
\text{(go one mile/in an hour for an hour) = go one mile (in an hour).}
\]

What this says that going at the rate of a mile in an hour for an hour produces the event of going a mile which fits inside an hour. As explained in the section on differential, run one mile in an hour is either a complex event that lasts one hour, or it is a rate, which is a type of state. In abstraction of the subject, it denotes velocity; with a heavy subject, momentum.

We now want to get back to the event by “multiplying” the rate with \( \text{for 2h} \). Technically, what this will mean is that \( \text{for} \) must be an integral operator, to be an inverse of \( \text{in} \), which is a differential. Which is what it is, by my definition:
The adverbial in this thus represents a differential or quotient operator and for represents an integral or sum operator.

Continuing this way, we can make literal sense of much of the classical mathematics of change and motion. Starting and stopping are absolute, speeding up and slowing down gradual changes between (relative) rest to (relative) motion.

Let us pursue this for a moment. The event types start and stop can be defined as ¬e.e and e. ¬e, respectively. This makes start equivalent to become. For the special case of motion, set e = move. Since motion requires two points to verify, starting and stopping require four.

Acceleration and deceleration bring in an inertial frame, a norm or choice set as explained in the section on comparative change. An object moves relative to an inertial frame if it has positive velocity relative to it. The event type speed up can then be defined as ¬speed(speed → speed.speed, which says that relative to a fixed choice of speed, the accelerating object first does not reach that speed, then it does. Acceleration as a rate of change of speed is then obtained as the derivative of this event type relative to time.

Differential and integral event calculus will play a role in my discussion of the dynamics of events later on. See sections on internal objects and dynamics.

Manner adverbials

The above observations provide a key to Palmer’s (1987:§4.2.2.) observation that unmarked forms are used when the topic is the manner or cause of an event, not its temporal location or duration. Manner adverbials (Eckardt 1997) pick the process (an open event type) out of an accomplishment. The writing comes about by pencil, the letter by writing: John cause pen cause write cause letter.

John was writing a letter. He wrote very fast.
See how they run. (The Beatles)

ru Ivan napisal pis’mo. Pisal karandashom. ‘John wrote (pf) a letter. He did the writing (ipf) with a pencil.’

ru Pochenu zdess’ tak pyl’no? Ty ubiral segodnja komnatu? ‘Why is it so dusty here? Was it you who cleaned the room (ipf) today? (Forsyth 1970:84)

ru Krasivo ukrashli elku. Kto ukrashat’? ‘They have decorated (pf) the tree beautifully. Who did the decorating (ipf)? (Rassudova 1984:81)

fr Il peignit à la fois l’histoire, le portrait, le paysage, les fruits, les fleurs, les animaux, et il était habile dans tous les genres. Il inventait facilement et executait avec la même célérité. ‘He painted (pf) at once history, portraits, landscapes, fruits, flowers, animals, and he was skillful in all the genres. He invented (ipf) easily and executed (ipf) equally quickly.’ (Valentin: Les peintres célèbres, X, 2, 228)

English did the decorating shows that the properties of the process are at issue, the accomplishment is old information (Hedin 1998). The aspect contrast can distinguish adsentential and adverbial uses of deliberately in Deliberately he ate the soup and he ate the soup deliberately. Deliberation applies to the act (closed) or the activity (open). French imperfect could also be translated with dispositional would.

Comparative time adverbials

Adverbials indicating comparative duration like (for a) long (time), briefly (for a short time) imply metric time but vary with scale (norm or unit of measurement). Short means shorter than some norm, long longer than one. Given transitivity of comparison, short is downward persistent, while long is upward persistent. An important consequence is that short entails bounded, conversely unbounded implies long. Another connection is that long entails complex (extended), conversely simple (atomary) entails short. A long event is matched against a shorter one which it exceeds by some part. An event is near another if they are separated by a short time. In the section on achievements we noted that many cycles and achievements have near or short built into their meaning.

Here are some of the consequences of these dependences. Accomplishments are extended so they can take arbitrarily long, while achievements are simple, so they can be arbitrarily short. Long and briefly are duration adverbials, so they don’t intersect with closed events. One cannot say You took a shower

133 The relation to the open/closed distinction is less immediate. Connected unbounded events are open and closed ones are bounded.
long, I reached the door briefly, one has to say It took you long to take a shower, I reached the door quickly.

*Early* and *late* are adverbial forms of homonymous comparative adjectives. An event is *earlier* than another event if it occurs before the latter, so adverbially *earlier than* simply denotes <`t. x earlier than t` where x is a measure equals xt. *Long before* t and *much earlier than* t are synonymous, both represented by *e.long.t* or equivalently by *e.t*. *Shortly before* t and *a little earlier than* t is of course *e.short.t* and *immediately before* t is *e.t*. The positive form *early* is a relative adjective, i.e. its extension depends on what the choice set (norm) happens to be. *I left early* means my departure now antedated others in some reference set, perhaps earlier than on other days, earlier than others, or earlier than expected. As *early as* t is a synonym for *already at* t.

Compare *John slept early* to *John slept late*. The former is taken to mean *John fell asleep early*, the latter *John woke up late*. Why? Neither specifically refers to beginnings or ends. The former says that there was an early time when John slept, and the earliest such time is when he fell asleep. The latter says that there was a late time when John slept, and the latest such time is when he woke up.

**Point time adverbials**

Point time adverbials like *at noon* are aspectually like achievements in that they denote a vague region of appropriate resolution around a point in time. *We had lunch at noon* fits the lunch around, possibly starting at, noon sharp. Strictly, a point time adverbial should generate a closed event. *It is noon* is strictly true at one point only. Aspectually, it is still open, for as an event type, *It is noon* does not contain its boundaries *It is morning* and *It is afternoon*.

As Comrie (1985:30) points out, it is not accurate to say that a momentaneous time adverbial turns an extended event into an inception. Rather, the event remains what it was, but it is timed by its beginning. *The prime minister will make a speech at 6* is not equivalent to *The prime minister will begin the speech at 6*, but rather to *The prime minister will make a speech beginning at 6*. Finnish uses a source case *kahdeksalta* 'from eight' to mark the starting point of an event and a goal case to indicate the end point: *Menen töihin kahdeksalta/kaheksaksi* 'I go to work at eight/for eight'. Vlach (1993:245) claims *Max drove to the store at 3* means the drive started at 3. This appears sensitive to perspective. Compare *Max drove to town at 3*. If the trip is coming toward the point of reference, the timing may be the time of arrival. These impressions follow if we supply the starting point *Max drove in/out to town at 3*. The drive out starts at the point of departure, the drive in starts at town limits.

There is a granularity effect here. Harkness (1987:58) contrasts

- She smiled at six o’clock. (ok)
- She ran a mile at six o’clock. (odd)

*At noon* is better for the latter. The following generalisation suggests itself here. A point time adverbial names the first or midpoint of the cycle it denotes (the next or surrounding unit of time in the resolution associated with the adverbial). An extended time adverbial just denotes its extent. Thus *at noon* identifies a period around noon sharp later than morning and earlier than afternoon. I feel there is a difference between *The meeting will be at noon tomorrow* and the conference will be at noon tomorrow. The conference is likely to last longer than noontime, so *start* would sound better than *be* here. *The prime minister will make a speech at noon* has the form *speech\(\cap<noon<. Max drove out to town at 3* has the form (in\(\cap(drive\cap town))\cap3, Max drove in to town at 3* has the form (out\(\cap(drive\cap town))\cap3, both of which make sense because driving in/out contracts to a point.

In contrast, an accomplishment *They will build the bridge next Monday build\cap\cap Monday* is just rather unlikely. One would say *They will begin building the bridge next Monday* or *They will build the bridge starting next Monday*. (Schopf 1987:180,182). Summing up, an event type can be contracted to a point if it contains simple events of the same type, and it can be extended at will if it contains an open subevent. States can be both contracted and extended, achievements can be contracted but not extended at will, activities and accomplishments can extended but not contracted.

**Adverbial aspect**

The point of the preceding sections was that adverbials denote event types, and as a consequence, adverbials have aspect. Besides the main distinctions between loose and tight fit, count (frequency) and measure, location and duration, interesting special cases have been noted. A nice minimal pair (McCoard 1978, Matthews 1987:153).) is

I’ve bought a new car lately/recently.
Lately/recently both denote a near past (an extended now), but lately only goes with open event types, recently allows both. Lately is tight, recently is loose.

Has anything new happened lately?    Dennis Brain died recently.

Lately is a particularly clear example of a temporal adverbial that has inherent aspect.\(^{134}\) Once this point is appreciated, it is easy to accept that all adverbials have aspect, some just are more permissive than others (Vlach 1993). Lately is tight but allows gaps. I have slept badly lately entails I have slept badly in the last few days, not I have slept badly throughout the last few days. Although lately fits tightly the intermittent event type \((pf\, sleep)^\dagger\), it has loose fit relative to the event type sleep. I have slept badly for the last few days or \((pf\, sleep)^\dagger \|(day)^\ddagger\) is usually taken to mean I have slept the last few nights badly or \((pf\, (sleep)(night))^\ddagger\). During accepts both closed and open event types, which means it is looser than for, which only accepts open ones.

Lately as a tight near past time adverbial only allows open event types, so it coerces bought a new car to a habit. Recently as a loose adverbial and allows bought a new car to denote a single event. Note the flip of perspective. One can say that lately and recently denote the same period(s) in the near past, but they locate events differently within them. Or one can say that they themselves denote (hence intersect) different event types: lately is an open near past event type a.now, recently a closed recent past b.now.

For the present and presently are their mirror images.

So far and henceforth are tight near past and future adverbials too, different from lately and for the present in that they cover the entire past or future, while the latter covers a limited while. The former correspond to Priorian H and G, while the latter are the topological tenses H\(^\dagger\) and G\(^\ddagger\) of Burgess (1984:116). Temporary adverbs for the time being, provisionally and temporarily are unanchored adverbials that derive cycles of open events.

Another set previously, formerly, before, in the past, in the old days are aspectually open and contrast the previous generic event type to the current one. It is somewhat curious to say I was born previously or I met my wife before. There is a strong suggestion, coming from the open aspect of the adverb, that the event has happened more than once. The aspect auxiliary used to does the same work. My parents used to die is unlikely.

Compare I moved to Chelsea because my parents had died previously where previously is an anchored adverb meaning before that. Describe previously as \(<^*now^*>\). Then I have been there previously matches, but not I was born previously. My parents had died previously matches, because pluperfect is not a near perfect.

Harkness (1989) compares generic present time adverbials nowadays, these days, and today. She finds out that they differ in aspect type, resolution, and contrast. All three are aspectually open (they only go with open event types) and imply a scale upward from days. All of them conversationally implicate that make a difference i.e. that the event they modify had a beginning or will have an end (or both). Which implicature is strongest depends on the adverbial. Nowadays and these days are generic, today is a temporary state. Nowadays has coarse resolution (social scale). These days suggests a smaller resolution (personal scale). All three suggest a comparison to the past or to the future (or both).

Harkness finds nowadays predominantly in opposition to the past. Finnish nyttemmin and Swedish numa ‘more now’ are nonpast, while so far is nonfuture. Examples:

For the time being/nowadays Harry is too young/old.
How is your garden nowadays/these days/today?
He is the best photographer working today/nowadays/these days.
He opened his business in Fleet Street in 1789 and that’s where the shop is today.

The first example contrasts nonpast for the time being and present nowadays. The second example illustrates resolution: nowadays might count years or redesigns and elicit a ground plan, these days might go by seasons or weather and elicit a blooming schedule, today narrows it down to a point and elicits states in reply. Except that today has a looser use too, if the event type allows it. I am hungry today probably really means today, Many people go hungry today may not.

In the third and fourth examples today is better than nowadays or these days, because it disambiguates for a simple state against a habit or temporary state (attaching today to is rather than working in the third example). Huddleston (1967:800) notes these adverbials require present tense: I (had) live(d) in London today cannot mean nowadays. At the moment differs in the same way from now or at this moment. Compare also the contrast between always/all the time and sometimes/from time to time discussed in the next section.

\(^{134}\)Lately means in recent times where the plural character of the adverbial is in evidence.
Always

The quantifier adverbs *always* and *never* can answer all of the questions *how many times*, *how often*, *when* and *how long*, i.e. they can do duty for absolute and relative frequency adverbs, frame adverbs and measure adverbs (Matthews 1987:156).

First, *always* can mean *every time*, i.e. be a (relative or absolute) frequency adverbial \((t \rightarrow p)^* = 1\). Given \(t\) is a state, this equals \(t \subseteq^* p^*\). The left side of the equation can also be rewritten as \((\neg \cup (t \cap p))^*\) or \((\neg \cap. (t \cap p))^*\), so \(t\) is a possibly disconnected series of occasions of \(p\). Etymology suggests that this is what *always* comes from. Its dual *sometimes* is an iterative (serial) quantifier \(pf^* p\) in 1.

Second, *always* can mean *at all times* (any time), i.e. be a location adverbial \(p\) at 1 (*When is the store open? Always.*) Its dual *sometime* or *ever* will mean \(p \in 1\) or \(< p <\). For instance, the difference between *Have you been here?* and *Have you ever been here?* can be that of *here, now* and *<here<now*.

Third, *always* can mean *forever* (*all the time*), i.e. be a duration adverbial. *p for ever* where *for ever* is the event type of eternity \(1^*\). (See section on eternity.) *Sempre foi cerrada* ‘It was/has been closed all along’ - it does not (have to) mean it was closed many times - it can mean it was closed for the whole duration, which can be a time in the past or one extending until now.

The three formalisations are (conditionally) equivalent in the calculus.

In *You always win* one is implicitly quantifying over a series of occasions *when you play*. Winning is continuous relative to the occasions, but the occasions may come and go. The join of occasions of not playing with occasions of playing and winning is continuous and exhausts all times. Similarly *Sempre gostei de estar à janela* means: *Whenever I was at the window, I enjoyed it*. Here too *always* means *each time*, i.e. it quantifies over a set of observation times (Newton 1979:159-60, Leinonen 1982 112ff.).

An instance of this relativity is the natural language fact that *It always rains sometime* or its dual *It sometimes always rains* are distinct event types, and both distinct from the one quantifier versions *it always rains* or *it rains sometime(s)*. (Note the singular-plural distinction in English between narrow scope durative *sometime* and wide scope frequentative *sometimes*.) If *always* and *sometime* ranged on the same domain here, one of the quantifiers would be vacuous. This observation is related to granularity. A nested temporal quantifier ranges on a refinement of the cover associated with the outer one, using a finer resolution. *It always rains sometime* is true of Barbados where it rains part of the day every day of the year. *It sometimes always rains* is a fair generic statement about Darwin with its yearly rainy season.

The logic of this type of a nested neighborhood system, where going to finer granularity entails more information, is that of the modal logic \(S4\) characterising transitive Kripke frames., or intuitionistic logic (van Benthem 1986, 1991, 1996). If *it always always rains* is a fair description of the state of affairs, then *it always rains* is too, *a fortiori*. The converse need not hold: *It always rains* may be roughly true, but not quite *it always always rains*. The logic of *always* thus satisfies reflexivity *always p ⊆ p* and transitivity *always always p ⊆ always p*. Timeless event types are idempotents of *always*, satisfying *p = always p*.

The neighborhood logic of nested temporal quantifiers is quite a strong system for expressing temporal properties, if there are enough neighborhoods. For instance the validity of *The weather always changes for a while* could mean that weather is nowhere continuous (a Cantor discontinuum or middle third set).

The following are equivalent (have equivalent readings):

- It always rained last year.
- It rained all the time last year
- It rained all last year.
- It only rained last year.

As etymology shows, the difference between *always* and *all the time* is a count-noncount distinction: *All the time* is noncount. *John always sleeps (at all occasions)* vs. *John sleeps all the time (continually)*. This produces apparent scope differences:

- The phone always rang when I was in the shower. \(pf\ shower \rightarrow pf\ ring = 1\)
- The phone rang all the time when I was in the shower. \(shower \rightarrow ring = 1\)

The first one assings a ring to every shower. The second one entails continuous ringing during one or more showers. Molendijk/de Swart (1998) point out a similar case in French.
fr Pauline jouait dans le jardin. Jean la harcelait tout le temps/toujours. 'Pauline was playing in the garden. Jean teased her all the time/always.'

*Tout le temps* 'all the time' suggests Jean was in the garden teasing her throughout that occasion, while *toujours* sounds more like an explanation why Pauline played (alone?) in the garden: Jean had a habit of teasing her at all occasions. There is a similar difference in granularity between *de temps en temps* 'from time to time' and *parfois* 'sometimes':

fr Pauline faisait ses devoirs. Parfois, De temps en temps, sa mere l'a aidait. 'Pauline was doing her homework. Her mother helped her from time to time / sometimes.'

*From time to time* is more apt to quantify over the current occasion, sometimes over other similar occasions. Molendijk/de Swart call *always/sometimes* independent, *all the time/from time to time* dependent adverbials. The definite singular *the time of all the time* no doubt has a share in this. Finnish *koko ajan/aina* 'all the time/always and aika ajoin/toisinaan' 'from time to time/occasionally' make similar distinctions between *this occasion' and 'other occasions' (toisinaan literally means 'at other occasions'. One of the equivalent representations of *That year it always rained (when we were out)* is thus the conditional formula

\[
\text{year} \rightarrow (\text{out} \rightarrow \text{rain}) = 1
\]

where *out* is the (often contextually provided) presupposition or antecedent condition which constrains the universal claim (Quine 1965:91, Bennett/Partee 1972). The universal quantification over the year can also be entailed by the tightness of reference time \( t \), i.e. \( t \) is temporally atomic:

\[
e \cap t = \emptyset \text{ or } e \cap t = t
\]

This yields an alternative formalisation as

\[
\forall \text{year} \cap (\text{out} \rightarrow \text{rain})
\]

Consider next two closed events *It always starts to rain when we go out*:

\[
\neg \text{out} \rightarrow \neg \text{rain}. \text{rain} = 1
\]

This event type is also able to cover a longer stretch, for it is equivalent to *either we don’t go out or it starts raining*.

Different languages take different options between closed and open aspects with *always* and *never*. There are no cut and dried grammatical rules here, but compositional combinatorics. A trend resulting from that combinatorics is that grammatical aspect languages prefer closed aspects (aspect scopes over quantifiers), lexical aspect languages open ones (quantifiers scope over aspect).

In Portuguese, *sempre/nunca* sentences quantifying over a closed period in the past have Perfeito. In a universally quantified perfective, the universal quantification is restricted to a bounded time.\(^{135}\) English *It always rained* is unmarked for closure. The Portuguese *sempre chovou* ‘It (has) always rained’ is closed, but the closure comes from context: it always rained until now *pf (sempre chover).now* or it (always) rained then *always rain)*then<now. Contextual instead of lexical closure is an index of grammaticalisation.

*Sempre chovava* is also grammatical, but it is an open, often iterative or habitual proper past (*sempre chover*’).\(^{135}\) Compare also English *I have lived in London for an extended period and I intend to remain: though it can hardly be maintained that the period of my living in London has come to an end* (Diver 1963:152), its past half up to now obviously has (Hirtle 1975:94).

The Portuguese rule for aspect choice in universally quantified past clauses is thus really very simple. Either the clause has closed aspect and is true for a closed time (not necessarily true *only* for a closed time, but true for a *given* closed time), or it has open aspect and denotes an open event. Compare *Ele

\(^{135}\) A similar idea appears in Hill (1958):

In “I have been hungry all day”, there is the same component of non-past time, but it is more difficult to arrive at the component of completeness, since as has been said, the action is still going on. Completeness, however, is still there, though it is now translated from the action to the period of time. That is, whenever a *have* phrase occurs with a time indicator which indicates a period, like *all day, two hours, twenty years*, or the like, it is the period which is complete.

(Diver 1963:152 finds this “a very bold suggestion”. I find it bold and beautiful.
sempre faz os deveres ‘He always did.has done his homework’ pf sempre fazer to Ele fazia sempre os deveres ipf sempre fazer ‘He used to.would always do his homework.’ or sempre ipf fazer ‘He was always doing his homework (when we would check)’. The former sums up a period, the second describes a habit or trend.

Santos (1996:468) glosses Perfeito composto Ele tem sempre/nunca tem comprado peras ‘He has always/never been buying pears (on the occasions we are talking about)’. My conclusion is that Perfeito composto scopes over sempre/nunca here, restricting the quantification to a contextually specifiable near past. (Perfeito simples can restrict it to a remote one or cover the entire past).

In Russian, the perfective is used with vsegda/nikogda ‘always/never’ in dispositions:, the imperfective in habits.136 Details are given in the section on Russian adverbs..

The difference between American I was never satisfied and British I have never been satisfied is that the former denotes a definite past before now e<now, while the latter denotes a near past up to now e.now. The two coincide when the definite past is the entire past.

Always scopes over the progressive in Why are you always bothering me. It does not mean ‘Why are you in the process of always bothering me’ but ‘Why are you always in the process of bothering me’, i.e. why are you bothering me on every available occasion (Leech 1970, Woisetschlaeger 1977, Kucera 1981). The opposite scoping is virtually ruled out by the fact that always produces a simple state: there is no process associated with universal quantification.

The same overtones are found in Finnish and Portuguese; I suspect universally:

He is always losing things/making fun of me
She’s forever breaking things/The car’s always breaking down.
fi Täytyyko sinulla aina kysymyksiä? ‘Do you have to be always asking questions?’
pt Ele estava sempre a fazer os deveres. ‘He was doing his homework all the time’

A universal progressive sounds irritated or impatient, suggesting overdoing things. Kucera (1981) actually stars his examples Bill is always arguing well, I am always teaching only one hour on Friday where there is no call for impatience.

The feeling of interruption comes from the suggestion that the observations are not clocked by (conditioning events appropriate to) the events themselves, but by times when something else ought to happen (Jespersen 1949:§13.1.1, Palmer 1987:§4.3.3: “what is happening happens very often, but it does not happen at set times‖). Palmer contrasts

I always break the eggs first. (The proper way to do it.)
I am always breaking the crockery. (Not the plan!)

Analysis: q → proq break = 1. This type of sentence is discussed in Poutsma (1921:§35), Jespersen (1949:§13.1.4), Chung/Timberlake (1985). Compare also Jespersen’s contrast

I am always saying what I shouldn’t say; in fact, I usually say what I really think.

Here the progressive observes unintended behavior, while the simple aspect states a policy. One difference is that the simple aspect has its occasions built in: I always say what I think say → think = 1 means ‘when I say something I say what I think’, whereas in I am always saying what I shouldn’t u → prog say\|shouldn’t = 1, the timing comes from outside. ‘At all occasions I am saying what I shouldn’t’ raises the question when, for it leaves it open what the relevant observation times are.

Diver (1963:157) predicts

No one was ever asking such a question before.

does not occur naturally. It probably hasn’t, outside chronological treatises. There are many ways to improve the sentence: leave out ever, replace was with has been, was asking with asked; leave out before, change a question to questions. This combination happens to be particularly difficult to find a context for. A likely formalisation is (e<now→prog pf ask)\|then<now which says that at any time before now, no one is in the middle of uttering a question of the relevant type. To make sense of this rare notion one should contextualise the times quantified over in some plausible way. One might be

Why did you interrupt this interviewer even more rudely than any so far?

136Lindstedt 1985:40 claims that Bulgarian and Russian have to use imperfective aspect with relative frequency adverbials often and seldom.
When
The relative adverb *when* is a dual of *at*. An event happens *at the time when* it happens, i.e. *when* e equals *at t: e at t*. *When* is homonymous, and etymologically identical, to a free relative (question) adverb ‘at which time’, ‘at the time that’ (Heinämäki 1974, Ritchie 1979, Hinrichs 1981, Partee 1984, Moens 1987, Hamann 1989, Sandström 1993, Declerck 1997). The null hypothesis then is that this is also what the conjunction *when* means. Though in many cases this paraphrase works all right, there are problems too, some related to aspect. English *when* seems partial to closed event types. There are four combinations of closed and nonclosed aspect given two clauses:

**open when open:**

Laura always *thinks* I am shouting when she *doesn’t like* what I am saying.
Joanna’s love affairs always run the same course. She has a mad infatuation for some completely spineless young man who is a misunderstood genius. She listens to his endless complaints and works to get him recognition. Then, *when* he *is* ungrateful, she *is* deeply wounded and says her heart is broken - until the next gloomy young man comes along, which is usually about three weeks later. (Christie: *The Moving Finger*)
When I *looked* in his face, with its pale, delicate features I thought I *could see* traces of the same mental struggle that I had gone through. (Poutsma 1921)
When I *saw* Robert come across the lawn I *knew* it was the telephone and I *felt* physically sick.

**closed when open:**

*I made his acquaintance* in Tver, *when* I *was* there on official business. Daylight came with no visible sunrise as Mark was climbing to the highest ground in his journey. ‘A luz do dia *chegou* sem nenhum nascer do sol visível *quando* Mark *estava a trepar* para o terreno mais alto da sua jornada.’

**open when closed:**

*She was thinking*, just when he *came upon* her, of this.

*pt Quando eu os observava, já eles se encontravam irreverenciavelmente condenados*. ‘As I was watching them, they were already irresponsibly condemned.’ (Wells, back translation!)

**closed when closed:**

*But when* her father *left*, she *made ready* for what was most necessary - to go to Kitty and compose her.
She merely *smiled with a forced smile* when he *finished*, and *made no reply*, because she had not heard what he said.

*pt Quando a refeição *chegou* ao fim, Frost *conduziu-o* à antecâmara da Cabeça e uma vez mais foi despido e vestido com um macacão cirúrgico e uma máscara. (Lewis)*

*pt Quando* a câmara do raio da morte *tocou* na água, esta *transformou-se* imediatamente em vapor. (Wells)

The combinations closed *when* open and open *when* closed (called the incidence schema, Pollack 1960:132-133,1976, Johanson 1998) are least problematic. English examples of progressive open-*when*-open sentences are hard to find: many candidates on closer inspection appear iterative. The examples illustrate this. Poutsma (1921:7) actually comments on his example: “If the writers … had distinctly felt to *look* to be of a durative character, they would, most probably, have used *as* instead of *when*”. English *when* differs from for instance Portuguese *quando* here.

In the last group, when both events are closed, a very common implicature is that the main event follows the subordinate event, and that there is a cause-effect relation between them. 137 The relation resembles narrative progression and is used for the same purpose. In this interpretation, simple past becomes close in meaning to pluperfect, or else, *when* could be replaced by *after*.

There are several ways to explain the effect. A *temporal* explanation is to say that *when* sometimes simply means *(right) after* (Partee 1984). A *modal* explanation is to say that *when* is really a causal contingency connective, and the

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137 The effect may be more noted in preposed *when* clauses but is not limited to them. In general, word order seems to affect aspect mainly through normal discourse principles (aboutness, old and new information, iconicity). For instance, *Earlier, I used to smoke (but not any longer)* suggests I have quit much more than I *used to smoke earlier (and I smoke now)* simply because *earlier* is in contrastive position in the former.
temporal relation is an entailment from the principle that cause precedes effect (Moens 1987). An *aspectual* explanation is to say that when has aspectual import (Declerck 1997). All of these proposals have been made, and each has something to speak for them.

The temporal theory predicts that simple past and pluperfect are interchangeable in some cases:

> When he (had) opened the window he heard a noise.

However, the equivalence is never complete. With the simple past, the subsequent event is contiguous or overlaps with the preceding one (Hirtle 1975:52, Ritchie 1979, Matthews 1984, Hamann 1989). With the perfect, there is a gap, however small, where something else may have happened. Compare:

> “Now, it’s all over- God be praised!” was the first thought that came to Anna Arkadyevna, when she *had said* good-by for the last time to her brother, who *had stood* blocking up the entrance to the carriage till the third bell rang. (after/at the time)

> When he (had) left everyone hoorayed (in applause/relief).

> When I had seen/saw the television show, I called the police. (after/because; Roberts 1967:80)

> As soon as he (had) heard that, he turned pale. (after/because; Curme 1931:361)

With *had heard*, “the involuntary nature of turning pale seems to be destroyed, almost as if he were waiting for just that to turn pale” (Hirtle 1975:52 citing Hewson). A similar Bulgarian example is cited in Lindstedt (1985:83), translated as *Why didn’t you explain the reason for me when I (had) asked you?* The pluperfect allows a gap (means *after I asked you*), the simple past doesn’t (means *at the time I asked you*).

Formally, the causal theory suggests when is contextually equivalent to because:

> **hooray when leave = hooray because leave**

which in my explication of the causal relation entails temporal non-precedence of effect and cause:

> when \( \cap (\text{leave} \leq \text{hooray}) \)

or its dual, which places the point of when somewhere between the leaving and hooraying:

> \(<\text{when}< \cap (\text{leave} \leq \text{hooray})\)

The causal theory correctly predicts that the sequential implicature is defeasible. It is easy to find examples of closed nonsequential when sentences once it is realised that the cause-effect relationship is not the only meaningful relationship between events.

The causal theory predicts that the asymmetry of when is due to the asymmetry of cause and effect. This seems right. Asymmetry does not depend on aspect.

> The train is in motion when the locomotive is pulling it the train. The locomotive is pulling the train when the train is in motion.

> I was happy when she came. She came when I was happy.

> She left when I left. I left when she left.

In each case, the validity or failure of e when f = f when e depends on the presence or absence of a causal dependency between the events.

The causal theory can be given a pragmatic slant: the relationship is imputed into a when sentence to make sense of the connection; no particular modality is built into when as such. Causality is just one of the ways how events can bear on one another. Here is a selection of cases (cf. Declerck 1997:§6.2).

> When he telephoned for a taxi, he called his lawyer. (Hamann 1989:62)

> You always betray your age, my dear, when you refer to the weather. (Weldon: *Rules of Life*)

> When they built the fifth bridge, they took several tenders.

> When they built the fifth bridge, they used the best materials.

> When they built the fifth bridge, there was a gala opening. (Ritchie 1979:89)

> Whenever Mary wrote a letter, Sam answered it two days later.

> When John makes a phone call, he always lights up a cigarette beforehand. (Partee 1984)

> When the meal ended, Frost took him to the antechamber. (Lewis)

> The meal ended when Frost took him to the antechamber.

Weldon’s and Hamann’s examples describe one and the same event in two ways. The examples from Ritchie (1979:89) allow a loose match of closed events (the main events fit within the course of events characterised by the when clause). In Partee’s examples the adverbials *later* and *beforehand* specify the relation of event times:
In the last pair, both sentences seem fine, though the latter appears to imply that the when event (departure) follows the main event (meal). (pace Smith 1991:103). But this is only illusory. A better way of looking at the pair is to note that the departure was the end of the dinner: the boundaries of the events coincide, though the events they bound are sequential.

This suggests we may get away with the hypothesis that when means at the time that if we pay attention to aspect (Bartsch 1995). My version of the hypothesis starts with the observation that (at the time) when is a time adverbial which denotes a time when relating the two clauses. Consequently, there are three event types to relate in a when sentence instead of just two. As the examples show, when can denote a narrower or wider period round the timing event (‗sloppy identity‘ in Declerck 1997:114):

When he telephoned for a taxi, he called his lawyer.  
When they built the fifth bridge, they took several tenders.  
Whenever Mary wrote a letter, Sam answered it two days later.  
When John makes a phone call, he always lights up a cigarette beforehand.  
The meal ended when Frost took him to the antechamber.

when is a still a live (free) relative pronoun. In I leave when(ever) you leave there is a live occurrence of when as a free relative. Here is an example where when is really a free relative at which point or and then. When is simultaneous with had finished, which makes it later than the events in the main clause.

Only one number on the program failed to interest her. When Gilbert Blythe recited “Bingen on the Rhine” Anne picked up Rhoda Murray’s library book and read it until he had finished, when she sat rigidly stiff and motionless while Diana clapped her hands until they tingled.

Due to the mediation of when, the relation of the times it relates may be loose (‗sloppy simultaneity‘, Declerck 1991, 1997:114). Sometimes it seems outright contradictory to assume the two events related by when should take place at once:

When he fell down he got up.

It appears simply false to say that the sentence denotes (up\down)\(down\up), because the two events exclude one another. Rather, the sequence of events is up\down\up, the two adjacent events sharing a common boundary state down. When says the subject fell down, then got up.

This indicates that the two sides of when are asymmetric. A change in a when clause times its consequent state, while one in the main clause is timed by its inception. A change happens when it starts but holds when it is over. Asked (exactly) when a change happened, one narrows the time down to the point of change, asked what happened then (when the change happened), one can stretch the final state at will. The representation up\down\when\down\up is consistent with this and is equivalent with up\down\up.

Evidence for an aspectual account of the sequential when comes from the interaction of when with aspect types. The sequential reading gets better when the timing event is a simple change (an end or a beginning), and worse when it is extended. In particular, when seems virtually unable to order two accomplishments in a row. The following sentence is not a typical narrative sequence of events, it sounds more like the description of a habit.

When John ran to the school, he took a shower and changed clothes.

Changing accomplishment ran to achievement got would make a definite difference. An accomplishment times the activity, while the achievement times the final state. The time of the running cannot the time when John took the shower, but the time of getting there can be. Compare the following cline:

When I built one cabin, I built another. (odd)  
When I built one cabin, I started building another. (less odd)  
When I finished building one cabin, I built another. (better)  
When I finished building one cabin, I started building another. (best)
There are granularity effects. Relating events of different granularity with when is not always comfortable:

When my alarm clock went off, I built a cabin.
When my alarm clock went off, I set about building a cabin.

It is not enough for when for the events to follow one another, they must in some sense happen ‘at the same time’, at the same level of resolution. An alarm clock going off does not time the result state (ringing). That time is not enough for building of a cabin, but it can time the start. This may be what Vlach (1993:258) is after in his concept of sequel. When I reach Chicago is ‘that situation which obtains just after I reach Chicago’, allowing for ‘vagueness due to the fact that there is no clear time when things have changed enough that the current situation is no longer that one’. Depending on granularity (what events can be left out of consideration) immediately when I reach Chicago can mean different things. Cf. also consequent phase in Moens and Steedman (1988). What is at issue is whether the following event is the next one in some relevant resolution of events (Partee 1984:fn28, cf. also Cooper 1986, Dowty 1986:47, Stump 1985:55, Declerck 1997:115).

Given when denotes an event type, one can ask whether it is open or closed, atomary or extended. The fact that ‘open when open’ cases above denote series suggest that when, in contrast to while, is closed.

Suppose then when is a closed temporal adverbial of form pf when. There are two possibilities: it is a half-closed change \(\neg\text{when}.\text{when}\). This duality matches the duality of open and closed event types. When when meets a half closed event type \(c = \text{when}.\text{when}\) the result is the event type \(b = (\text{when}\cup\text{when})(\text{when}).\text{when}\). When this in turn meets an event type e, the result is event type \(e \text{ when } c = (\text{when}\cup\text{when})(\text{when}).\text{when}\).

When when meets an open event type a the result is \(\text{when}.(\text{when})(a).\text{when}\). When this in turn meets e, the result is the event type \(e \text{ when } a = \text{when}.(\text{when})(a).\text{when}\). Note that this match is symmetric, while the dual one is not: there are two ways for two events to meet at a boundary.

Another way of putting the same idea is this. when denotes a simple closed event type, that is, a filter of closed events round a point, so when = \(<\text{when}<\). When the event when meets a change, the point \(<\text{when}<\) of when matches the point \(<\text{when}<\) of the change so \(<\text{when}< = <\text{when}<\. When when joins two changes, the point of when joins the two events, so \(<\text{when}< = <\text{when}<\). When the event is an open one, when matches a closed bit of it, so when = pf when = pf when a = pf when a e. Altogether, when joins events dually by serving as the boundary between them or as a region containing them.

Here are examples of the two types.

But the nearer he came, the more excited she grew. Only when he stood by her head she was suddenly quieter, while the muscles quivered under her soft, delicate coat.
When Anna was passing the top of the staircase, a servant was running up to announce the visitor, while the visitor himself was standing under a lamp. Anna, glancing down, at once recognized Vronsky, and a strange feeling of pleasure and, at the same time, of some dread, stirred in her heart.

In the first example the events related by only when, stood by her and was suddenly quieter are or imply changes, while while...quivered is an open event simultaneous with the last change. In the second example, the image is not one of a steady simultaneous progression of Anna and the servant walking opposite ways and Vronsky standing about the while, but a closed event of Anna coming to the staircase, noticing the servant on his way up and then the visitor standing under the lamp. Compare substituting while for when here. Intuitively, when names an occasion at which two other events take place at the same time.

Heinämäki (1974:129) observes that when cannot match now. (Now) when is replaced by Now that to refer to the actual present. I am reading while Ada is watching TV can describe the present, I am reading when Ada is watching TV is generic (Heinämäki 1974:51). It can’t be just that now when is redundant, for now while/that are as redundant (Declerck 1997:128). I believe it shows that English when denotes occasions, i.e. closed events (Dilys 1998):

Just when it seems someone is about to get somewhere with intelligent environmentalism, 10 other people mount podiums and declare humanity a disease on the face of the earth. (Declerck 1997:132).

Note the simple aspect on closed event types is about to get somewhere and mount here. In general, cases where when does combine with simple present includes timeless or event timed uses like summaries, stage scripts, or historical present (Declerck 1994:148).
Here is a real life example of now when. Now that would do as well, but now when is not bad. As Declerck aptly puts it, when helps to define a kind of situation, one instance of which happens to actualise now (Declerck 1997:131).

He doesn’t want any trouble with the senior staff, particularly now when we’re getting ready to move into the new lab. (Declerck 1997:132).

The event type of series forms another case. When assumes a conditional meaning under universal quantification: When(ever) it rains, it (always) pours describes a universal implication expressed by rain\(\neg\text{when}\)\(\Rightarrow\)pour\(\text{when}\). The
when clause binds the antecedent of the universal quantifier always/ever (quod vide), cf. Partee (1984:272). Aspectually closed, universally bound when(ever) is iterative ‘at every occasion’ (Declerck 1997:130). McCoard’s example below can represent simultaneous regularities \( \text{pf}^r \text{sleep} \rightarrow \text{pf}^r \text{work} \) or a habitual sequence \( \text{pf}^r (\text{sleep}< \rightarrow \text{<work}). \)

When children are doing nothing, they are doing mischief.

Bill works on his thesis when he is on his own at night. (Declerck 1997:130)

When I sleep soundly I do my work better. (McCoard 1978:102)

The following contrast noted by Declerck (1994:148) harps on the same theme:

My friend has been working when / while I have been in here.

Only while can refer to this time (only), when talks about other times (too).

**While**

The adverb while (Heinämäki 1974, Ritchie 1979, Hamann 1989) seems to mean ‘during the time that’. It is the open dual of when.

Bennett and Partee (1972:4.4) note that while has to denote an extended event. It does not have the around the time option of when. Unable to connect adjacent closed events, while is a tighter expression of simultaneity than when. It relates events of all aspect types, but there is a preference for at least one of the events to be open. If both are closed, while assumes contrastive or concessive meaning (but, whereas, although), i.e. expresses consistency of opposed arguments (truth ‘at the same time on the other hand’) rather than temporal simultaneity. Formally \( e \text{ while } f \) reduces to \( e \cap f \).

open while open:

Prince Kuzovlev sat with a white face on his thoroughbred mare from the Grabovsky stud, while an English groom led her by the bridle.

Hence, while Marilla and Mrs. Rachel were enjoying themselves hugely at the mass meeting, Anne and Matthew had the cheerful kitchen at Green Gables all to themselves.

closed while open:

And I told him a lovely fairy story while we were waiting, so he didn’t find the time long at all.

“There has been nothing like this in the country since our Motherhood began!” Somel said softly to me, while we watched the symbolic marches.

open while closed:

Sviiazhsky was sitting sideways, with one elbow on the table, and a cup in one hand, while with the other hand he gathered up his beard, held it to his nose and let it drop again, as though he were smelling it.

She listened attentively, looking at him over the baby, while she put back on her slender fingers the rings she had taken off while giving Mitia his bath.

Wait here while I switch on the light.

closed while closed:

He turned away while Lizaveta Petrovna put the baby to the unaccustomed breast. Suddenly laughter made him look round. The baby had taken the breast. 

The ladies got in, while Vronsky and Stepan Arkadyevich followed the crowd to find out details of the disaster.

A perfect in a temporal while clause requires one in the main clause too.

He has been unbearable while he has been working on his book.

The most straightforward way to unpack this sentence \( \text{prog work} \cap \text{unbearable} \cap \text{now} \) gives a satisfactory semantics: there is a near past where both events have occur simultaneously. It also explains the tense congruence requirement in a straightforward way: the only way to match an extended now is with another extended now.

An interesting fact is the interchangeability of while and until in \( \text{Wait here while/until I switch on the light} \). This can be explained, for a vague change \( \text{switch on the light} \) \( \sim \text{light}\cap\text{light} \) can be seen as process justifying while or as a change

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138 This definition makes \( e \text{ while } f \) symmetric. Bennett and Partee (1972) define while asymmetrically \( (e \text{ is temporally included in } f) \) which entails that John left while Mary slept is not equivalent to Mary slept while John left. I find it hard to distinguish the entailments of the two sentences. In particular, the direction of inclusion, if any, seems to stay the same. Their discourse functions of course differ.

139 This example can also be an instance of while denoting a result state.
licensing until. Contrast this with the complementarity of while and until in open event types. Wait here while it is dark/until it is light.

While resembles as long as in that it presupposes an upper bound (Heinämäki 1974:50). Once is just the opposite. One says Have fun while you are young/alive and You can rest once you are old/dead, rather than vice versa.

As

The English as falls between when and while. It is unlike while and like when in that it can connect two closed events. It is unlike when and like while that it can connect two open events. It is unique in that the events connected by as must be contingent and simultaneous, belong to the same here and now, the same scene. The events are perceived together, which makes as scenic. When this condition is not fulfilled, as becomes a discourse connective ‘seeing as’. As is almost the only choice in As the time passed. Cf. also just as.

As I went over to say good-by I saw that the expression of bewilderment had come back into Gatsby’s face…

As he left the room again she got up and went over to Gatsby and pulled his face down, kissing him on the mouth.

As I watched him he adjusted himself a little, visibly. His hand took hold of hers, and as she said something low in his ear he turned toward her in a rush of emotion.

And as the time passed and the servants came in and stood waiting in the hall, his eyes began to blink anxiously, his eyes began to blink anxiously, and he spoke of the rain in a worried, uncertain way.

As we started in through the gate into the cemetery I heard a car stop and then the sound of someone splashing after us over the soggy ground.

This woman rushed out at us just as we were passing a car coming the other way.

As she sat in a corner of the comfortable carriage that hardly swayed on its supple springs, while the grays trotted swiftly, in the midst of the unceasing rattle of wheels and the changing impressions in the pure air, Anna ran over the events of the last days,…

As cannot very well replace when in a pluperfect or a generic clause:

When Klipspringer had played ‘The Love Nest’ he turned around on the bench and searched unhappily for Gatsby in the gloom.

When/while the cat is away the mice dance on the table.

Before and after

At first sight before and after seem relatively unproblematic. before e denotes \( e^- \) and after e is its mirror image \( e^- \). In context, e before f denotes \( e^- < f^+ \) and f after e denotes \( f^+ > e^- \). Equivalently, the adverbials can be framed as intersective location adverbials \( e^- \) before f and \( f^+ \) after e. The two formulas are equivalent to \( e^- f^+ \) and \( f^+ e^- \), respectively.

Before and after can be prefixed by measure phrases like two minutes before/after which combine to form tight initial and final bounds of events come.2min.leave (Hamann 1989). Before alone equals some time before come.<.leave. Immediately before is of course come.leave.

Hans came two minutes before/after John left.

Asymmetry of before and after

Pointwise, before and after seem converses (Leech 1969, Wunderlich 1970, Bennett 1972). Anscombe (1964) was early to point out that conversion often fails. Heinämäki (1974:112) found that conversion is apt to fail precisely when before and after relate open event types. Let us go through the cases. Suppose

\[
\text{Al was home before Bill was.} \quad \text{Bill was home after Al was.}
\]

compare two open events \( \text{al}<\text{bill}. \) In terms of pointwise quantification, precedence between two open events would only say that there is a time of Al at home which precedes a time of Bill at home. (This is the weakest rule lifting pointwise order to interval order from the section on ordering events, quod vide).

This is a very weak precedence relation, as it allows the two states to overlap. \( \text{Al was home both before and after Bill was home and vice versa} \) would be entailed by \( \text{Al and Bill were at home together for a while.} \) To guarantee irreflexivity and asymmetry, at least one of the events has to be coerced to a closed one.

Because of the asymmetry of time, the event in a before clause is taken to be closed, so that \( \text{before Bill was home} \) stands for ‘before the/any time that Bill was home’. Pointwise, this says some time of Al at home precedes all times of B at home. This yields a reading which compares who got home first, i.e. is tantamount to

\[
\text{Al got home before Bill did} \quad \text{Bill got home after Al did}
\]
For after, this reading is only obtained by coercing the main clause event to an inception: \( \text{/_bill>} \text{al}. \) The same course of events is equivalently represented by \( \neg \text{al}<\text{bill.bill} \) which equals \((\neg\text{al.al})\&(\neg\text{bill.bill}),(\neg(\neg\text{al.al})(\neg\text{bill.bill})) \) and minimally denotes the sequence \((\neg\text{al}<\text{bill}).(\text{al}<\text{bill}) \) ‘first neither is at home, then Al is at home and Bill is not’. Before can be modified with already...even and after with only...already on this reading:

\[
\text{Al was home already before Bill was \quad Bill was home only after Al already was.}
\]

An example is England was a world power before USA existed. The likely reading is England was already a world power before USA even existed. This is not at all synonymous with the converse USA existed after England was a world power, unless the latter is read as USA only came to exist after England was already a world power.

The strongest reading \( pf \text{ al} < pf \text{ bill} \) compares two cycles, saying a closed time Al was home precedes a closed time Bill was there. Pointwise, this applies the strongest lifting rule saying that (within a given reference time) all times of Al at home precede all times of Bill at home. This means the same as

\[
\text{Al visited home before Bill did \quad Bill visited home after Al did}
\]

which unpacks to \((\neg\text{al.al})(\neg\text{bill.bill}),(\neg(\neg\text{al.al})(\neg\text{bill.bill})) \) and denotes the sequence of states \((\neg\text{al}<\text{bill}).(\text{bill}<\text{al}),(\neg\text{al}<\text{bill}).(\neg\text{al}<\text{bill}) \) ‘first neither is at home, then Al is home and Bill is not, then Bill is home and Al is not, then neither is home again’. Before can be modified with only and after with only...no longer can be modified by only on this reading:

\[
\text{Al was home only before Bill was \quad Bill was home only after Al no longer was.}
\]

There is one aspect combination left to consider, \( pf \text{ al} < \text{al} \text{ bill} \) which unpacks to \( \text{al}<\text{al.bill} \). Since the later event is open here, this combination can only be expressed with after: Bill was home after Al was home, i.e. Bill either stayed on or got there later. It is equivalent to Bill was home after Al left home. After can be modified by still/even...no longer on this reading:

\[
\text{Bill was still home even after Al no longer was.}
\]

As predicted by the perfective paradox, there is no reading with open event types which compares departure times: there is no reading equivalent to

\[
\text{Al left home before Bill did. \quad Bill left home after Al did.}
\]

These findings agree with Anscombe’s (1964) observations. Anscombe claims that while before is transitive and asymmetric, after is neither. It is indeed easy to prove that before satisfies transitivity and asymmetry independently of choice of aspect. After fails transitivity and symmetry when two different aspects are mixed:

\[
\begin{align*}
\text{Al is home after Bill is (gets) home} & \quad A \quad a \quad a \\
\text{Bill is home after Cy is (gets) home} & \quad b \quad b \quad b \quad b \\
\text{Cy is home after Al is (gets) home.} & \quad c
\end{align*}
\]

Table 41

Following Heinämäki (1974:113), we can sum up the situation thus: before is transitive and asymmetric; after is transitive and asymmetric if and only if its main clause is closed. A real converse of before (modulo implicatures) is at most after.

**Counterfactual before**

Before is a well known negative polarity item. This has been related to the fact that before is a comparative adverb (Geis 1970). Generally, the small end of any comparative relation (the comparative than clause in more than ...) is a negative polarity context. There are a number of technically different but essentially similar ways of defining a comparative relation bigger than in terms of a pair of correlated positive and negative adjectives relatively big/not big, separating those that are on the positive side of a norm or choice set (big) from those that are in the complement (not big) (Kamp 1975, Fishburn 1977, Dowty 1979, Klein 1982). Compare section on comparison. This cannot be the whole story here, however (Heinämäki 1974). If after is the converse of before, it ought to create a polarity context as well. Converses in general do, e.g. earlier/later are both negative polarity: John arrived earlier/later than anyone else. After does not: John arrived before anyone else but John left after everyone else.

This asymmetry of before and after was already listed above as one of the asymmetries of time. The intuitive reason for the asymmetry is clear (Heinämäki 1974:98): if a book is returned before I read it, I have not yet read it, and perhaps I will not read it at all. If it is returned after I read it, I have read it. This is also why conditional mood appears in before sentences but not with after. The past is there already, the future is not there yet. Past (nonfuture) and future are dual:
the past (nonfuture) is full of events and empty of time, the future is empty of events and full of time. The order 
topology of time is made out of past events, where the minimum is the beginning and the maximum is the end.
It remains to make formal sense of the intuition. A good starting point is to note that \textit{read<return}, given \textit{read} and \textit{return} are closed, can be rewritten as 
\[(\text{read} \land \neg \text{return}).(\neg \text{read} \land \neg \text{return})?(\text{return} \land \neg \text{read}).\]

The factual use looks at the events at the reference time of the \textit{before} clause: I \textit{read the book before I returned it} says the 
same as I \textit{returned the book while/when/and I had read it}. The counterfactual case I \textit{returned the book before I read it} \textit{return<read} looks at the situation at the reference time of the main clause, i.e. when I \textit{returned the book I had not yet read it}. The \textit{before} clause is a negative context. Returning prevents reading, so here the reading event remains 

\[(\text{return} \land \neg \text{read}).(\neg \text{read} \land \neg \text{return}).(\text{read} \land \neg \text{return})?\]

Compare \textit{after}: by a parallel rewriting, \textit{John became famous after he made this statue statue<famous} goes to 
\textit{\neg \text{statue<famous}}.(\text{statue} \land \text{famous}), i.e. first John had no statue and was not famous, later he had a statue and was famous. At the reference time (after), the statue and the fame are both there, i.e. the after clause is a positive context.

The noncommittal use of \textit{before} in I \textit{left the country before anything happened} (Heinämäki 1974:92) says is that nothing happened before I left; if something happened, it was after I left. This hedges the 'yet' bit: 
\textit{\neg \text{leave} \land \text{happen}),(\text{leave} \land \text{happen}?).}

The counterfactual reading of Sue left before she punched anyone, where Sue left before she would have punched someone at the party, adds a counterfactual exclusive disjunction leave\leftrightarrow punch: it was either leave or punch someone. Since she left, she did not punch anyone, but had she not left, she might have.

As Heinämäki (1974:90) points out, the counterfactual implicature can vary: in We had to install a new battery before the car started the phrase is the same: \textit{\neg \text{install} \land \text{start}),(\text{install} \land \text{start}?) but the counterfactual backing is the opposite: \textit{\text{install} \leftrightarrow \text{start}.}

Heinämäki (1974) shows that there are interesting differences between factual and nonfactual uses of \textit{before}. The factual \textit{before} presupposes the \textit{before} clause, the nonfactual one is noncommittal or implicates its denial. The factual \textit{before} goes with positive polarity clause, the nonfactual one allows negative polarity items. The factual \textit{before} has indicative mood, the nonfactual can have a conditional \textit{would}. She observes that the counterfactual uses tend to involve closed events, presumably because the main clause event prevents the \textit{before} event (causes its complement). Consider for instance

\text{John sat on the chair before anyone else sat on it.}

The common core of the message is that John was the first to sit on the chair. The counterfactual reading is the one 
where John sits down on the chair specifically to prevent others from getting seated on it. That reading is hard to get
unless sitting is construed as an action. Heinämäki (1974:84) wonders why durative predicates should be bad here: “one 
could very well imagine situations where some state of affairs, by lasting long enough, prevents some later event that 
would have happened otherwise.” Instead, such situations are described using for fear that (lest):

\text{John sat on the chair lest anyone else sit on it.}

Apparently, \textit{before} is no good here because the main event of a \textit{before} sentence is a closed event which happens \textit{early} 
(too early, or early enough), not an open event that goes on (too long or long enough). And in fact, if we look for states 
that come about \textit{too quickly} we find durative predicates in counterfactual \textit{before} sentences:

\text{John was sitting on the chair before anyone else could sit on it.}

\text{John was drunk before he noticed.}

These can be counterfactual: no one else sat on the chair, and John never noticed being drunk.

Causal implicatures are sensitive to grammar, so they are easily lost or shifted in conversion. In the following, John tells 
a joke to prevent an awkward silence, but only manages to cause one:

\text{John told a joke before there was an awkward silence.}

\text{There was an awkward silence after John told a joke.}

Heinämäki (1974© notes that causal implicatures depend on polarity:

\text{John was a communist before he met any/some Chinese.}

\textit{Any} allows that John is still a communist, \textit{some} suggests he stopped being one. Why? \textit{Some} entails he did meet Chinese. 
In the absence of other information, he was a communist \textit{until} he met the Chinese. Gricean implicature: he was a 
communist \textit{only} until the did. \textit{Any} is noncommittal or doubtful about meeting Chinese. Paraphrase: He was a communist
even before he met any Chinese, i.e. not only after he met some. Gricean implicature: he was a communist afterward too.

French uses subjunctive in avant 'before' clauses. A redundant negation ne appears when the clause is counterfactual.

Eva était tout à fait heureuse avant que, un jour, John lui téléphonât. 'Eva was completely happy before one day John phoned her.

Elle regarda à côté avant qu'il ne lui dise bonjour. 'She looked aside before he would greet her.'

Compare also counterfactual when clauses (Declerck 1997:176):

When he would have rung off she went on.

The British kept the negotiations alive when they would have collapsed.

**Before/after and aspects**

Although interdefinable, before and after interact differently with the perfect aspect.

She returned the book before I (had) read it.

She returned the book after I (had) read it.

The perfect has little appreciable effect on after, but makes a potential difference with before: before I read it rather suggests before I started the book, before I had read it before I finished it. (These associations are defeasible.) These readings follow compositionally from the definitions given. What is not predicted is that sometimes before I read it can also mean 'before I finish it', especially under negation: The following seem to say the same thing:

Don’t return the book before I read it.

Don’t return the book while I haven’t read it.

Return the book only after I (have) read it.

There is the feeling of the reading event shrinking to a point, i.e. being treated as an atomic event. The event is not there until it is over. This is consistent with the feeling that not before is equivalent to only after here, which is strictly only true if the events are relative atoms (cf. appendix on relation algebra). The option of returning it when I am halfway through is simply not countenanced. The equivalence of simple aspect and perfect is another instance of the same. Before I read it equals before I have read it only if reading contracts to point. Compare

I was reading the book for hours before I read it.

I started reading the book at once but took hours before I read it.

Here there is a strong urge to add had. The reference to the internals of the reading event determine a granularity which prevents contracting it to a point.

Diver (1963:164) compares

He arrived after the lecture had begun. (He was late.)

arrive>(s//lecture) r

The lecture had begun before he arrived. (He was late.)

(s//lecture)<arrive r

He arrived before the lecture had begun. (He was early.)

arrive<(s//lecture) r

The lecture had begun after he arrived. (He was early.)

(s//lecture)>arrive r

The perfect is absorbed by the transitivity of temporal order and can be left out with little loss of meaning. There is one subtle asymmetry. The main clause pluperfect with before is genuinely ambiguous: the reference time of the surrounding narrative can be the arrival or some later time. In contrast, the main clause perfect with after only appears to have a flashback reading. This is predictable, for the narrow scope perfect implies nothing about whether he was on time.

Smith (1991:113) rejects the use of progressive in

Herbert was hiding the loot after the telephone rang.

True, progressive is not the natural choice if the point is that Herb hid the loot because of the call. The following seems much better, as right/even remove the causal implicature:

Herbert was hiding the loot right/even after the telephone rang.

---

140 The concept of an atomic transaction is known in the theory of database systems (Elmasri and Navathe 1989:545).
Summing up, I agree with Heinämäki (1974:94,95) that before/after are monosemic. The different uses express the same temporal relation; further differences lie in the asymmetry of time and the vagaries of contexts.

**Preferential before**

Consider the saying *I'll die before I give up*. This seems to say that I do not intend (want) to give up. How does this sense come about? We can (truly) say that this is a case of metaphor: the sentence orders the events die and give up by preference, not time. But this metaphor is exceptionally well entrenched, as it is supported by a simultaneous metonymy in the model of rational action. This metonymy is expressed by the saying *first things first*: if an agent has a choice, he pursues his primary goals before secondary ones. The last thing anyone does is die, both metaphorically and literally. Here are some of the background assumptions of the case:

- ~live. live. ¬live you only live once
- die = live. ¬live death is the end of life
- give up → live(¬try) giving up is living and not trying
- live U? die no one wants to die
- e U? f → e < f first things first / the sooner the better

The metaphorical entailments *I won't give up, I don't want to give up, I'd rather die than give up* can be derived from these premises. The strategy of *I die before I give up* can be written as the following event type:

**succeed U? try U? die U? ¬try**

Following this strategy, one succeeds or else one tries again. If one then succeeds, well and good, one can stop there. Else one tries again, and so on until one succeeds or dies. *Give up means live and not try*. That event won’t come before death, so in fact it won’t come at all. Note the metonymy between preference and time here. It is a special case of the principle *first things first*. This principle is only superficially contradicted by the maxim *work before play*. In both case, the things that count go before the rest.

*First things first* codes the logical relation between the disposition of preference and the action of choice. To choose is to take: to get (to) the choice, to become with it. Conversely, to want is to be disposed to choose. The relation is the same as between pull and become near. Note also the relation of *first things first* to lexicographic preference expressed by \( a.a \ U? \ a.\neg a \ U? \neg a.a \ U? \neg a.a \ U? \neg a.\neg a \) and its generalisation, alphabetic order (\( a U?\neg a)^*? \).

An inclusive preference for \( a \) and \( b \) in this order can be coded as the state \( \text{have } a \land b \) and the corresponding choice as \( \text{take } a \land b \). The best plan is to take both. Assuming one can only take one thing at a time, the choice can be implemented as \( \text{take } a \cdot \text{take } b \). This plan of action gives the best expected utility if the risk of failure grows with time, as it does if probabilities are evenly distributed over a branching future (Fishburn 1996, Lyons/Peres 2002).

The same argument can be stated in terms of exclusive preference. An exclusive preference for \( a \) and \( b \) in this order can be coded as the state \( \text{have } a \land \neg b \) and the corresponding choice as \( \text{take } a \cdot \neg b \). Here, one may not want \( b \) if one has \( a \), or having both may be excluded. The only reasonable plan is to first go for \( a \) and try plan \( b \) only after a fails. Note also the equivalence of \( \text{try until success } (\text{try}(\neg \text{ok}).ok \text{ and not give up before success. } \neg(\text{try}.\neg \text{try }\text{ < }\neg \text{ok.ok}) \). This is an instance of the duality of until and before, as well as that of try and give up. Compare the section on negation. *Before* and *after* can also be construed as comparatives *earlier than* and *later than* from *early* and *late*. A logical analysis of *before* based on comparative relations is given in Lewis (1973:§5.2).

**Time within the sentence**

Temporal relations between events within a sentence are expressed by infinitival forms and subordinate finite clauses. There is a considerable literature on temporal conjunctions connecting finite clauses in particular, from Reichenbach (1947) through Rohrer (1977), Hornstein (1977), Heinämäki (1974), Hinrichs (1981), Dinsmore (1982), Partee (1984), Harkness (1987), Moens (1987) and Sandström (1993), to name a few. Much of the discussion has centered around temporal adverbials and adverbial clauses and the question whether they modify reference time or event time. I take up the question in the last section of this chapter. The first few sections discuss infinitivals.

**Taxis**

By definition, infinitival forms are not finite, i.e. do not make indexical ("absolute") reference to the speech situation (time, participants). In relative tense or taxis, the events described are related to the time of the governing construction. Aspect contrasts are used for relative tense in contracted clauses (Chung/Timberlake 1985). As a rule, there are fewer distinctions made than in finite clauses. For instance, English *Here are my letters announcing my intention to start*
contracts which announce(d) and The shock of such an event happening so suddenly is easily intelligible to any one could expand to (should have) happened/ was happening (Comrie 1976:39).

In accordance with the unmarked tense/aspect system, the default relative tense/aspect combinations are past closed, present open or future closed. To put the point figuratively, events happen at the present but in the past or future. In the unmarked case (i.e. unless otherwise marked), closed events are placed outside the relative present, and open events around it.

It is traditional wisdom in grammar that the temporal and aspectual relations between events entailed by infinitival forms may carry all sorts of modal implicatures that explain the (mention of the) relation in a given context. Grammars speak of causal, final, concessive, adverbial and explicative meanings and there are surely others still. Such modal implicatures may also become part of the conventional meaning of a construction. Closed nonpast participles have modal implicatures, past ones don’t: agenda ‘things to be done’, acta ‘things done’. Nonpast closed events are by default placed in the future, and plans (active) and obligations (passive) concern the future. The post hoc ergo propter hoc principle is a source of causal and concessive implicatures.

One can distinguish with infinitival forms and infinitival constructions, which are grammaticalised uses of infinitival forms. Infinitival forms can be divided into participles, gerunds, and nominals depending on part of speech (inflection) and grammatical function: participles are adjectival, gerunds are adverbial, nominals are nominal. Infinitive remains a morphological cover category for uninflected forms functioning in various grammatical roles.

**Participle**

Participles are verbal adjectives, that is, one-place object type projections of event types:

<table>
<thead>
<tr>
<th></th>
<th>past</th>
<th>present</th>
<th>future</th>
</tr>
</thead>
<tbody>
<tr>
<td>active</td>
<td>x: x e &lt;</td>
<td>x: x e</td>
<td>x: &lt; x e</td>
</tr>
<tr>
<td>passive</td>
<td>x: e x &lt;</td>
<td>x: e x</td>
<td>x: &lt; e x</td>
</tr>
</tbody>
</table>

Table 42

This is one way of presenting participles. Other variants may be more revealing of the morphology. A past participle formed out of a causative accomplishment m = xmy = c cause e = x a cause y b can denote the right domain m 1, the suffix y c cause b, or the result state y: m\r where b = < r so r = b\r. Correspondingly, a nonpast participle can denote the left domain 1\r, or the prefix x : a cause e, or the preparatory state x: s\m where a = s\m so s = s/a.

Many typological universals of participles fall out from the interplay of aspect and diathesis. The points below are not new. I repeat them just to point out that they need no separate statement, all follows.

Participles of open event types are nonpast (e.g. thinking/hated), those of closed ones past or future (e.g. leaving/killed). Unmarked past participles are right projections, or result participles. They are past because at the time of the result, the event is already past. They are passive when they come from transitives and active from intransitives, because they denote the subject of the result. Unmarked present participles are left projections, or process participles, active as they denote the subject of the action (intransitive or transitive subject). They are nonpast, because at the time of the action, the event is not yet past. The English active past participle he is gone is exceptional only in being rare in present day English (Johnson 1998:§8.5.1.2).

In English, voice and tense pair up to produce two participles, active present and passive past. Finnish fills out the fourfield with active past and passive present participles. So do Russian, Bulgarian and Lithuanian.

Ancient Greek has active, medial and passive past and nonpast (future) closed participles (from the perfective stem) stesomenos ‘going to stand’, stesamenos ‘having stood (up)’, a present open participle (from the imperfective stem) histamenos ‘standing up’ and a perfect participle (from the perfect stem) histamenos ‘standing’.

Unmarked for reference time, a participle can be either bound or free, i.e. take its reference time from sentence context or from the time of speech. In

The person sitting on the sofa had been arrested for murder

the person sitting on the sofa can mean the person who is sitting on the sofa, the person who was sitting on the sofa or the person who had been sitting on the sofa. More complicated contexts can provide even more points of reference.

Finnish and Russian similarly interpret past participles with free or indexical reference. Sohvalla istuva/istunut mies oli pidätetty murhasta ‘The man (who was/had been) sitting/seated (pres/past ptc) on the sofa had been arrested for murder.’ Ljudi chitajushtshie/chitavshie zhurnaly nichego ne zamestili ‘The people (who had been) reading (pres/perf ptc ipf) papers (had) noticed nothing’. English uses adnominal participles to contract clauses, French cannot. (Vinay/Darbelenet 1953):
They made no effort to single him out among the incoming passengers. ‘Ils n’essayèrent pas de le repérer parmi les voyageurs qui arrivaient.

**Gerund**

Adverbal gerunds relate events to their parts or to simultaneous or successive events. In terms of event calculus, they are one place event type projections of event types. For instance, *work whistling* means *work and whistle*, so *whistling* is the type of events which happen accompanied by a whistle.

\[ e: \text{eff} \]

Finnish distinguishes by case between *as, by* and *in* gerunds; the first one has an old instrumental case, the second adessive (the current instrument case) and the third. The meanings are by and large in accordance with expectations given the meanings of the cases.

English gerunds abridge finite and/or clauses. A gerund does not translate back and forth to a conjunct clause when there are event type mismatches. Compare for instance a process gerund applied to a state and vice versa. *He walked about talking to himself or He talked to himself walking about unproblematically mean He walked about and talked to himself*. In contrast, *He talked to himself being mad means He talked to himself because he was mad* and *He was mad talking to himself means He was mad when he talked to himself*.

Perfect gerunds like *having eaten* describe anterior events. They go into (plus)perfect when or after clauses. Russian and Greek perfective gerunds and participles can describe anterior or posterior events (Chung/Timberlake 1985), while imperfective ones describe simultaneous ones. As always there are various modal implicatures licensing causal, final, concessive, adversative and explicative conjunctions:

> And all the while he kept up a merry commentary, emphasizing his words with jerky movements of his head. ‘Pendant tout ce temps-là il ne tarissait pas de remarques amusantes, qu’il ponctuait de brusques mouvements de tête.’

> He duplicated the performance the following day, getting away with a whole chunk. ‘Il répéta l’opération le lendemain et réussit à s’emparer d’un morceau tout entier.

> He left his bags in the luggage office, giving his real name. ‘Il laissa ses valises à la consigne et donna son vrai nom.’

> Turning left, he continued on the main road. (He turned left and continued on the main road.)

> Having (when he had) reached the door he took out a key.

> Zakonchiv nomer i soskochiv s loshadi, Polina klanjalas' publike. Oficery podkruchivali usy i krichali “bravo”, vzzyvaja ee na manezh. ‘Having finished (pf) her number and jumped (pf) from her horse, Polina would bow (ipf) to the public. The officers would twirl (ipf) their mustaches and cry (ipf) “bravo”, summoning (ipf) her back to the arena.

> Ja pereodelsja i predstal pered upravljajushchim, zasluzhiv ego odobritel’nyj vzglad. ‘I changed (pf) clothes and went (pf) before the director, earning (pf) his approving glance.’

**Event nominals**

The existence of an infinitive for a given tense/aspect is an indication that the form is an aspect (tenses are by definition finite forms, i.e. forms that bear a relation to an indexical reference time). English has infinitives for the simple present, progressive and perfect: *It feels silly to solve/be solving/have solved aspect puzzles*. Greek has infinitives from the imperfective, perfective, and perfect stems (but no future infinitive): *pheugein/phogein/ pepheugenai ‘be in flight/flee (escape)/have flown (be free)*. Finnish has a finite perfect, with a perfect infinitive *in statu nascendi*.

Infinitives are strikingly often etymologically resultative or passive goal case forms, reflecting an origin as a purposive adjunct in constructions like *give rice for x to (be) eat(en)*. Examples include *English (to eat), Finnish syö-TA-k* (passive-causative and dative morphology), and a large number of Indo-European infinitives (Krahe 1969: §64).

Deverbal event nominals name event types, that is, turn event types to object types which can participate in other event types. The difference is a grammatical one at best.

Event types are abstract objects. Accordingly, event nominals often are defective nouns whose reference is generic and noncount. Only event philosophers count walkings, everyone else and their dog count walks. With open event types, gerunds denote open events, while count nouns denote closed events: *I liked walking in the park / I liked the walk in the park*. The English gerund has a perfect but no (separate) progressive. The temporal relation to the head depends on the head.

> I anticipated/enjoyed/remembered finishing/having finished before five.

It has been claimed (Bennett 1988) that the English gerund denotes abstract ‘thin’ events, implying little more than the event type they name, while deverbal nouns denote concrete ‘thick’ events, which may include a larger variety of
subevents. Compare for instance Quisling’s betraying of Norway to Quisling’s betrayal of Norway, or Mary’s walking down University Avenue to Mary’s walk down University Avenue. In Mary’s walk(ing) was interesting, the noun walk can describe an experience, while walking may comment on the fact or the style. It makes sense to say She liked the walking, but not the walk, if she enjoyed the exercise, but not the company nor the conversation.

Link (1998:300fn) doubts the cross-linguistic validity of Bennett’s observation. It can be replicated for Finnish at least: Marjani käveli/käveleminen oli kiinnostava(a) ‘Mary’s walk(ing) was interesting’, where kävely is a deverbal noun and käveleminen a deverbal nominal, makes just the same contrast.

Aspectually, event nominals are like any objects, states. Walking pleases me is a state causative. In many languages, progressives of simple states and changes are formed with event nominals: instead of be sleeping we have be asleep. fi olla unessa ‘be in dream’, olla voitolla ‘be on victory, be winning’, while olla nukkumassa/voitamassa ‘be sleeping’ are absentive ‘be in bed, be (somewhere) winning’.

**Sequence of tenses**

*Consecutio temporum* or sequence of tenses is a traditional name for constraints on co-occurrence of finite tenses within a sentence. It involves choosing past tense and avoiding present tense in embeddings like

Mary feared that Bill was/is sick.
The family thought that the money was/is safe.


It will be useful to distinguish intensional indirect or quoting contexts from extensional ones. The former involve finite complements of propositional attitudes. The extensional contexts include relative or adverbial clauses. It is the indirect contexts that sequence of tenses primarily concerns. The division is not clear-cut in practice, but clear cases behave differently.

The *deictic centre* analysis says the outermost speech time determines the reference of all tenses (i.e. all tenses are indexical, or free). For instance, nothing needs to be said about the past tense was in extensional contexts like

Mary feared for Bill, who was sick.
The family thought of the money that was in the safe.

Bill’s sickness and Mary’s fear about it are both independently past, as were the family’s thoughts and the safety of the money. So why not just say that each tense independently depends on the deictic centre here and now.

Comrie’s arguments against a deictic centre analysis of English sequence of tenses include the following. First, a simple past can have future reference in John will say tomorrow night that he was singing in the morning, so was cannot count back from speech time. Jespersen (1949:§11.8) calls this forward-shifting of tenses. A second argument against a deictic centre analysis (Comrie 1985:106) is I told John that he should go, where past future go has no fixed relation to speech time. (See below for a more troublesome example by Kamp and Rohrer.) Third, in John said that he was singing, the singing can accompany the saying, but in John will say that he will be singing the singing is later. One and the same rule cannot account for both past and future tenses.

Comrie (1985) proposes a sequence of tense rule as an improvement to the deictic centre idea. Comrie’s sequence of tense rule for English takes the tenses of direct speech and shifts them back in time in past indirect speech (Chung/Timberlake 1985):

Sequence of tenses rule (revised version). If the tense of the verb of reporting is non-past, then the tense of the original utterance is retained; if the tense of the verb of reporting is past, then the tense of the original utterance is backshifted to the past, except that if the content of the indirect speech has continuing applicability, the backshifting is optional. (Comrie 1986:248f).

Palmer (1987:§3.2.3) argues that sequence of tenses is not an automatic rule of grammar, but involves ‘deictic shift’: a speaker who reports what was said replaces the deictics used by the original speaker with ones appropriate to himself.

Fabricius-Hansen (1989) distinguishes three rules for treating tense in indirect reports. Rule I, the *quoting rule*, is to copy (quote) the tense of the direct report. By Rule II, the *sequence of tense rule* proper, the now index of a past tense refers to reporting time while the then index refers to reported time. By rule III, the *free tense rule*, the embedded tense is deictic. (This is Comrie’s deictic centre rule.)

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1)Smith 1978:57 distinguishes between two principles, sharing and orientation. My reading of her distinction is that sharing binds RT and orientation ST.
I agree with Palmer (1987) that tenses agree or don’t by virtue of what they mean, not by an agreement rule. Tenses agree when what they individually mean makes them coincide in form, and disagree when they mean different. For example: Dicken’s use of dependent past in

I told her how I loved her … how I was always working with a courage such as none but lovers knew … how a crust well-earned was sweeter than a feast inherited.

was described by Jespersen (1949:§11.1.3) as a case where

“shifting (i.e. sequence of tense) is not required logically, but is due simply to mental inertia: the speaker’s mind is moving in the past, and he does not stop to consider whether each dependent statement refers to one or the other time, but simply goes on speaking in the tense adapted to the leading idea.”

Dickens uses past tense because he is reporting what was said then, not what is true now. Fludernik (1993:179) points out that in English tense shift is suspended in a great number of cases. The following deictic tense indicates that the reported clause holds true now:

I learned this morning that they have begun / will begin work on the bridge.

Conversely, tense shift avoids responsibility for another's utterance, reports it noncommittally or with critical intent (Declerck 1991:186-7). This is not just an association – it is the logical difference between the above sentence and the next one. It explains the common occurrence of past future (conditional) and past perfect (irrealis) forms as reported or evidential modalities. (See section on evidentials).

I was told this morning that they had begun / would begin work on the bridge.

Speakers use tenses that are adequate for their purposes, whether or not what they say might be true at other times as well (Declerck 1997). This also applies to Lakoff’s (1970:839; cf. Palmer 1987;§3.2.4) and Huddleston's (1989:335-6) examples

The animal you saw was my dog.
The man you’ll be talking to will be the Mayor.
How did you know what my name was?
Did I tell you I was here today?

What the case is now is beside the point. The topic time, i.e. the time talked about or denoted, does not have to coincide with situation time, i.e. the entire duration of an event (Klein 1994:Ch.3, Declerck 1997).

In sum, I buy Fabricius-Hansen's classification and the binding account of it. Some uses of tenses are free (indexical), i.e. time is counted from the indexical speech time. Some uses of tenses are bound, i.e. they count time from some point in the same sentence, or anaphoric, i.e. time is counted from some point in the discourse context. Some languages have separate free and dependent tenses/moods.. Sequence of tenses involves choice between free (absolute, indexical) and bound (relative, dependent) tense.

By this theory, what looks like tense agreement is an epiphenomenon of the use of free or bound past/nonpast tenses under past/nonpast main clauses. But this does not make tense agreement very different from person or number agreement (qua vide).

Finally, a shift is just a systematic translation between two arrangements, like a translation of a space or a matrix operation. The deictic shift theory is not a third theory incompatible with the others, just another perspective. For instance, Declerck’s (1997) description of tense subordination in terms of shifts of a temporal frame is fully intertranslatable with a binding account.

There are (at least) two bindable variables in tense, now (speech time) and then (reference time). Either one can be free or bound. I call a tense absolute/relative or definite/anaphoric according as which index is free or bound. The absolute/relative distinction concerns the denotation of the speech time variable now, the definite/anaphoric distinction that of the reference time variable then. A definite simple past tense then<now mentions two times, then and now. Thus there are four ways for a simple past to relate to other tenses, two for present.

Let us see how this (relatively) simple account fares with cases. If all goes well, no new rules are needed, everything already follows. It turns out that one is needed (see section on English sequence of tense.)

Even weaker theories can be conceived. Say dependent clause tenses are not bound but mean less than main clause tenses. One might argue for instance that a dependent clause present vaguely denotes an extended present. But a treatment along these lines seems to lose too many distinctions.

142Cf. Comrie’s 1985 distinction between absolute and relative tenses.
**Present**

Consider first English simple present. Here there is only **now** to fix, which can thus be free or bound. *John has often said/will say that he is tired* (can) exhibit relative presents. *John said/will say that we own this house* (can) exhibit absolute presents. The quoting rule does not apply: *He told me it’s 5 o’clock so I left* (Huddleston 1967:794) is ruled out.

The exclusion of the quoting rule contrasts English with e.g. Finnish, Russian and German, which allow bound present tense in past *verba dicendi et sentiendi* complements. (Russian almost has to, as it only has two tenses; otherwise there would be no tenses left to make relative tense distinctions).

There is one complication to this simple account. It is that an English present tense within a simple past context must cover the entire time from the past to the indexical present (Huddleston 1967, Smith 1978:66, Enq 1987:637, Abusch 1988). This is the ‘continuing applicability’ rider on Comrie’s (1985:114-116) sequence of tense rule.

I heard last night that Whitney is ill/gone means Whitney was ill/gone last night and continues to be so now. It is not enough that she was gone just then or that she is gone just now, or even both. It must be the *same* sickness or absence that covers both times so *sick/(then<now)* must hold (Smith 1978:66). Comrie too claims that the present cannot be used in *John said that he is absent today* (one has to say *John said that he would be absent today*).

The fact that ‘continuing applicability’ always applies in a past attitude context suggests that it is a property of the free present reading. So let us see if we can explain it from that hypothesis.

The good cases of present inside an intensional past context are factual. Nonfactual complements like the following appear odd (ibid. 795):

- Mary feared that Bill is sick.  
  The family thought that the money is safe.

The natural combination is Jespersen’s (1949:156) which places the false belief in the past and the true one in the present:

- The ancients thought that the sun moved round the earth; they did not know that the earth moves round the sun.

The free present reading expresses a past *de re* propositional attitude to a present fact. This give a cue to what is going on. It is not just the time of the event that escapes outside the propositional attitude. The entire event type is inverted to a *de re* one to match its etymological source:

- The earth moves round the sun, but the ancients did not know that.

The *shared* event which the ancients did not know and we do is the timeless (or at least long enough) event that the earth moves round the sun, not the subevent that it *did* so then, *nor* the one that it *is doing* so now.\(^{143}\) Closer to home, the following may be an acceptable way to tell that it is Sunday.

- Did you know that today is Sunday?  
  What you did not know a moment ago is the *same* fact that I am telling you now (*today is Sunday*). It is a *different* one in the following (*tomorrow will be Sunday*):

  - Did you know yesterday that today would be Sunday?  
    The generalisation is that *de re* event tokens allow substitution under identity, *de dicto* event types do not (Hintikka 19??). Compare

    - I found out last night that/why Whitney is sick today.
    - With *why*, what I found out is not the event of today, but another that entails it. Compare also

      - The ancients had the means to calculate that today is Sunday.  
        The ancients could have told us that today is Sunday.

    These two attributions of knowledge are acceptable and clearly *de re*. Compare also

      - What John said yesterday implied that he is/would be absent today.  
        What John said yesterday implies that he is absent today.

\(^{143}\) This is the way the ancients construed knowledge and necessity. For them, the objects of knowledge and necessity were timeless truths. Tensed propositions like *Socrates sits* are not necessary nor knowable, because they are now true, now false. (Hintikka 19??). The dual notion of equally timeless date stamped event tokens (Rescher/Urquhart 1971) did not occur or appeal to them.
We seem to have found an explanation for the continuity rider. It is a consequence of the identity conditions of event types in intensional contexts. This allows us to keep the simple hypothesis that the English simple present embedded in a reported simple past context is free (Huddleston 1967:793).

Is there a mirror image constraint on the future?

Gwendolyn will make note tomorrow that the Abbess of Crewes is (was) away today.

If *make note* means *notice*, the *de re* present tense is possible, if it means *say*, the simple past is indicated. Declerck (1997:80) also feels that in the following examples the present tense is not a relative tense.

Jim has known for some time that Joy is in Reno. *know(Reno)*\(\cap\)\(<\text{now}\)

Up to now he has always maintained that he works in a bank.

You know, ever since we started this treasure thing, I’ve had the strangest feeling we’re being followed.

**Bound present**

I assume that *now* occurs both free and bound. For one thing, the present tense in the universal *when* clause must be a bound tense because a free present cannot in general cover an extended now in English. Further, The present perfect can be free, in which case it matches the time of the main clause, or bound, in which case its reference time matches the time of the main clause.

I have always given him money when he asks. (ask\(\rightarrow\)give)\(<\text{now}\)

I have always given him money when he has asked. (ask\(<\rightarrow\)give)*\(<\text{now}\) or ask*\(<\text{now}\)\(\rightarrow\)*\(<\text{now}\)

I have often cried when I (have) felt lonely. (lonely\(\cap\)<\text{now}\)\(\rightarrow\)cry)*\(<\text{now}\), (lonely*<\text{now}\)\(\rightarrow\)*\(<\text{now}\)

I have once given him money when he asked. (ask\(<\text{then}<\text{now}\)\(\rightarrow\)*\(<\text{now}\))\(<\text{now}\)

What about future (Abusch (1988))? To capture the cause-effect dependence in *If I receive a letter, I will answer it immediately* it comes naturally to consider the present tense of *will* bound to that of the conditional clause, to capture the fact that the time of *will* varies as a dependent variable with that of *receive*.

\(\text{now}<\bigcap\text{receive}<\text{now2}→\text{now}<\text{now2}.\text{answer}\)

But if the cause-effect dependence is removed, the tense dependence disappears too.

If I get a reward, I will hunt down the outlaw.

\(\text{now}<\bigcap\text{receive}→\text{now}<\text{hunt}\)

The order of the action and the reward remains vague. Note that the dependent reading above is a special case of the free reading, just drop the mention of *now2*. It could be argued that *now2* is imputed by *immediately* and not the tense. Abusch points out that in *every mail I receive next year will be answered* the tense of *receive* can be a free present iff *now* can extend to the future (as it must anyway in a scheduled future present *I receive mail next year* now\(<\text{year}<\text{year}\)\(\bigcap\text{receive}\)<\text{now}\)). This free present reading is represented by

\(\text{receive}\bigcap\text{in}\ (<\text{now}\bigcap\text{year}<\text{year})→\text{now}<\text{answer}\)

On this reading, receiving and answering are unordered. The ordering *receive*\(<\text{answer}\) can be imputed by causality: it is difficult to answer unreceived mail. Compare Every guest I receive next year will be a nobelist where there is no way to tell when the guests are or become nobelists. A free tense treatment seems also right for

In March, we will discuss the abstracts which arrive by email.

As Abusch notes, the present tense *arrive* here can cover (at least) the time from now to March. Actually it can extend past March too, for we can discuss abstracts which have not arrived. Compare

In March, we will list the products which are on sale next year.

**Present perfect**

Declerck (1997:80) claims that in the following examples the embedded perfect is not a relative tense. The forms in the examples are absolute tenses with their own time domains roughly simultaneous with the main clause.

Ever since this morning I have been working while you have been doing nothing. *morning<\bigcap\text{work}\bigcap\text{idle}<\text{now}\)

Jim has known for some time that Joy has been in Reno. *know(Reno)<\text{now}<\text{now}\)

Since then I’ve felt I’ve missed some vital experience.

All the time I’ve been away, it’s been shrinking and shrinking.
Have all these things been fizzling away on this stove while we’ve been at the inquest?

By her lights, the only tense that can express simultaneity inside a perfect is the simple past.

I’ve often seen Washington when the cherry trees were in bloom. (Smith 1976:216)

You don’t think it’s on the small side? – It looks fine to me. – I’ve been thinking lately it was rather small.

Well, except for iteration (Declerck 1997:150), where simple past and present perfect may appear to be interchangeable: Consider:

I’ve spent hours looking at things like this – when you’ve not been looking.

I’ve gone there before when my sister’s been away.

\text{pf}^+ \text{there.now} \cap \text{when} \cap \text{pf}^+ \text{away.now}

I’ve gone there before when my sister was away.

\text{pf}^+ (\text{there} \cap \text{when} \cap \text{away} \cap \text{<now} \cap \text{now})

The first analysis does justice Declerck’s point. In the former, the event times match thanks to \text{when}, not by binding (sharing of \text{now} or \text{then}). It has got two apparent problems. First, \text{when} seems to connect open event types. Second, what makes sure that my presences match my sister’s absences? (The event type of the second sentence is free of both problems.)

The first problem is not serious. We can let \text{when} pluralise into \text{pf}^+ \text{when} without losing any explanations. The second problem is raises the problem of ambiguity. Is

\text{pf}^+ (\text{there} \cap \text{when} \cap \text{away} \cap \text{<now} \cap \text{now})

When I have bought my merchandise wholesale, I have made good profits.

\text{(wholesale} \rightarrow \text{profit})^+ \text{now} \text{or} (\text{wholesale}^+ \rightarrow \text{profit}^+)^+ \text{now}

really ambiguous or is it just the metalanguage which distinguishes two readings? I assume it is.

The second problem is no real problem either. Event types need not be convex (connected). The event type \text{my sister is away} is a gappy one consisting only of the times she is not there. It includes an equally gappy event type of my visits during her absence through the mediation of a gappy \text{when}. (See section on topology.)

A simple past is a proper past, so it cannot match the extended now reference time of a universal perfect, but it can pick up the event time of an existential perfect (Declerck 1994:85, 1997:76-77). Conclusion: no sequence of tenses here, just plain denotation. More examples:

Everything I have ever done was wrong. \text{do}^\cap \text{<now} \subseteq \text{wrong}^\cap \text{now}

When we have suggested changes, the people concerned were furious. (Declerck 1997:180)

\text{pf}^+ (\text{when} \cap \text{suggest})^\cap \text{<now} \subseteq \text{pf}^+ \text{furious}^\cap \text{when}^\cap \text{<now}

Every time I have been in London I have had a crummy hotel.

\text{time} \cap \text{hotel} \cap \text{<now} \subseteq \text{time}^\cap \text{London}^\cap \text{<now}

The one time I have ever been in London I had a crummy hotel. (McCord 1978)

\text{hotel} \cap \text{<now} = \text{the time}^\cap \text{see}^\cap \text{<now} \subset \text{this}^\cap \text{now}

Who else has come in while we were out?

\text{(out}^\cap \text{<now} \cap \text{while}^\cap \text{in} \cap \text{<now}

I’ve been reading about it while I was away.

I have known for some time you weren’t English. (Huddleston 1967:795)

\text{know} \cap (\text{foreign}^\cap \text{<now} \cap \text{<now}

When I have been unkind, as I have been many times, it was because I was not obeying. (Jespersen 1949:§5.4.4)

I haven’t met anybody yet who was not interested in money.

\text{~(meet\{greedy}^\cap \text{<now} \cap \text{<now}

There have been times in my life when I required soothing, and then I have felt that a whiff of tobacco stills and softens one like a kiss of a little child. (Poutsma 1926:259, Declerck 1997:79)

I’ve only ever met Mrs. Cuncliff when she comes round collecting signatures for protest petitions. (Declerck 1997:184)

Many a motel owner – when we’ve stopped there again – has remembered us and has said he preferred our dogs to most children. (Declerck 1997:77)

In the first example, the event type abstract is in the past, while the tense is a near one. The second is an example of tense anaphora. The order of the clauses cannot be inverted (Declerck 1997:180). Huddleston’s example is devious
because it trades on the density of time. Any point in time up to now is past although together they abut to now. Declerck’s last two examples are telling. The times in my life are past, the feeling is generic. There have been many motel owners, possibly many repeat stops and many praises of dogs, but the time of the professed preference of dogs matches the time of saying each time. Simple present would suggest the preference persists. In this respect compare also Declerck’s (1997:81) examples

Since then, his main fear has been that his blindfold will slip down accidentally.
He has been telling me for months that he was going to return the books to me, but he still has not done it.

The present intimates that the blindfold has not slipped and the fear continues, the past just reports the past. (Compare section on simple present above).

Note anaphoric then in Poutsma’s example which denotes an open sequence of occasions up to now. McCoard (1978:139) notes that that is a better relative pronoun than when in his example, which shows the clause is a restrictive relative clause. The quantifier ever and the extended now perfect are in the scope of the implicit equivalence of the one (= the only): ‘All of my stays ever in London up to now have been identical to the one in a crummy hotel.’ The entire definite description forms a definite past time adverbial, which dictates simple past in the main clause I had a crummy hotel.

Huddleston (1967:794) finds a present perfect in the because clause below cannot be a bound tense. This is probably due to the because clause taking scope over the tense of the sentence it explains.

John will fail because he hasn’t/won’t have gained enough capital.

Compare also

I have found what I had been looking for. look.find.now
I have found what I have been looking for. look[find.now]

These too mean what they say, and denote what they mean. The first one backshifts I find what I have been looking for. The looking is past now and near past at the time of the finding. Present perfect is possible too, if looking is not over.

I have heard that he has left for Australia. hear[leave<now]<now
I have heard that he had left for Australia. hear[leave<then<now]<now

The first one has a free perfect, which indicates that I have not been told otherwise. As far as I have been told he has not returned. The past tense of the second one can be free (anaphoric) or match the time of hearing.

Present perfect can perfectly well be bound to a nonpast main clause, so the following two are ambiguous: (I need not really say this it, for it is all fully compositional.)

John will lose everything he has earned. earn<now<lose or now<earn<lose
John will tell you whether you have passed the exam. pass<now<tell or now<pass<tell

A perfect under another perfect is ambiguous.

Percy has often listened to the radio when/while he has eaten supper. (Huddleston 1967)
Every time I have seen them they have been swimming. (Palmer 1974)

Palmer’s example can represent (see→swim[r])r ‘Every time I see them they are back from swimming’, or (see→swim)’r ‘Every time I see them they are swimming’, or even (see→swim)r ‘Every time I am back from seeing them (some other people perhaps), they are back from swimming.’

Bound present perfect

Another look at the arguments for a bound present perfect. Arguing cases where readings entail another is notoriously difficult. The burden is on showing that there are more readings than the weakest one. The usual method is to present another sentence that distinguishes the readings, but does that prove that the original sentence was ambiguous? The argument is always an inductive one: the simplest theory demands that it is. If we find an independent ambiguity, and a mechanism that produces it, what is there to turn it off in the simple cases? The best place to look for an ambiguity here are the intensional contexts. Let me take a harder look at

I have always felt that we are being followed.
I have always felt that we were being followed.
I have always felt that we have been followed

The first impression that strikes one is how little these seem to differ. At least, the can mean pretty much the same thing. Try representing them in the calculus.
The sentence 'I have always felt that we have been followed' can be quoted as 'we are being followed'. The first sentence captures it precisely if the simple past is bound to the universal quantifier always, as indicated by the corresponding event type. Now the point is: if the second sentence can convey precisely the same feeling, then the second sentence must get the analogous event type shown on the second line. But the the same goes for the third one, where there is no finite tense to receive the binding! Yet I have a definite feeling that the third sentence is a way to express just the quoted feeling. I feel it can be even clearer by

I have always felt that we have been followed when we have been followed.

This can try to convey that every bit of being followed was matched by a feeling of being followed just then. The perfect example also has a nested reading, reporting the feeling we have been followed:

I have always felt that life was simpler before my time.

The present tense might be timeless as in:

I have always felt that boys are boys.

What does seem hard to convey with present tense is that I have always had a feeling about something that holds just at the time of speaking and not at other times. This phenomenon was discussed in the section on simple present above.

I have always felt that today is/would be my lucky day.

With the present tense, the sentence is a somewhat unpolished report of an optimist, better phrased without the indexical today:

I have always felt that the day I lived was my lucky day.

If the day of speaking is meant, there is a strong inclination to change is to would be. In that case I would have quoted my feeling at the time as d will be my lucky day for some fitting description d of the day of speaking.

A present perfect bound to a future is found in Declerck’s (1997:85)

John is coming when he has eaten.

What will happen after the others have left?

Don’t follow him. He is too clever. He will soon find out that you have been following him.

Simple past

Next consider simple past. The English simple past can be absolute or relative on the one hand (Smith 1991:138) and definite or anaphoric on the other hand. John said in the morning that he was singing (then) has an absolute anaphoric past, i.e. now is indexical and then is anaphoric (refers to in the morning). In comparison, John will say tomorrow night that he was singing in the morning has a relative definite past, i.e. now is bound to a future time (the time of saying, tomorrow night), and then is a definite past relative to it (in the morning).

In Dowty’s (1982) example

The woman that stole the book saw the man that robbed the bank.

the three pasts can be free, and the events can be freely ordered. All that is implied is that they are (definite) past events.

Pluperfect

The verb ate in the next example can be analysed as a free definite past or the past of a bound present Percy said: ‘While I ate supper, I listened to the radio’ or ‘While I eat supper, I have listened to the radio.’ (Declerck 1994:139).

Percy said that while he ate supper, he had listened to the radio. (McCoard 1978:101)
Often there is a choice between tenses (Huddleston 1967:793):

\[ (eat \cap \text{then}_2 \rightarrow \text{listen} \cap \text{then}_2) \cap r \cap \text{then}_2 < \text{now} \]

He said that John had waited outside while Mary (had) locked up.

\[ (eat \cap \text{then}_2 \cap \text{listen} \cap \text{then}_2) < r \cap \text{then}_2 < \text{now} \]

Declarck (1997:75, 98) raises the question whether two nested pluperfects can share event times. They obviously can match, as in Declarck’s examples

He said that John had waited outside while Mary had locked up. (Huddleston 1969:792)

There had been a lad amongst Morse’s fellow pupils in the sixth form who had possessed a virtually photographic memory – a memory which Morse had much admired.

There are cases where there is no choice.

She claimed that he had said that he had done it all by himself.

The only tense structure Declarck gives this one is a back shift of

He says that he has done it all by himself.

It is certainly very hard to understand this sentence in any other way. There are many reasons why. There is the quoting effect from say, the perfective aspect of do it and the temporal order implicature of causation. If these factors are removed, we can get indirect binding here as well (Declarck 1997:98)

The robber had not seen that the surveillance camera had recorded his actions.

This too can be a back shift of the present tense report

The robber does not see that the surveillance camera records his actions.

Whether this should be called (indirect) binding is another matter. The event type John had waited outside while Mary had locked up can be written as

\[ \text{wait} \cap \text{while}_2 < \text{then}_2 \cap \text{while} \cap \text{lockup} < \text{then}_2 < \text{now} \]

where while matches the two event times. But if the event times match, the reference times match, and the present time obviously does, then the following event types match too:

\[ \text{wait} \cap \text{while}_2 < \text{then}_2 < \text{now} \cap \text{while} \cap \text{lockup} < \text{then}_2 < \text{now} \]

In other words, while does all the matching needed in this case. We don’t need to decide whether this is an instance of indirect binding, direct binding, or establishment of simultaneous domains, to borrow Declarck’s (1997:100) terms for the three event types. I am not making grammatical claims, I only point out that event types do not decide grammar here.

A past time adverbial can match the event time of a pluperfect or its reference time (Declarck 1997:88):

John had left at five o’clock.

This can be the back shift of John leaves at five \( \text{five} \cap \text{leave} < \text{then}_2 < \text{now} \) or John has left at five \( \text{leave} < \text{five} \cap \text{then}_2 < \text{now} \).

The selfsame ambiguity is multiplied into four readings in

The old fellow had died when they had found him.

which can be a back shift of he dies/has died when they find him / have found him. The scenarios: the man is found dead, or he dies of being found out. In contrast, there is only one likely reading for an open event type

When she had first considered committing suicide, the car had seemed a very real possibility. (Declarck 1994:141)

See also the section on English
**Future past**

Comrie’s second argument for sequence of tense is the following kind of case (Declerck 1997:§12.4.1, Schopf 1984:299).

> John will say tomorrow night that he was singing in the morning. (Comrie 1985)
> He will trip you on purpose and say it was an accident.
> Mrs. Dalloway will murmur that the party had been a success. (Smith 1978:54)
> The investigator will insist next month that he talked to the suspects 3 weeks earlier.
> Perhaps then, when we are quaint old folks and talk of the times when our step was lighter and hair not grey, we may be even thankful for the trials that so endeared us to each other, and turned our lives into that current down which we shall have glided so peacefully. (Jespersen 1949:§11.8.2)

Here *was* is a bound future past whose event time is in the future. What this does show is that the the deictic centre analysis cannot be the whole story: simple past is not always past relative to the indexical point of speech, but it can be bound to an embedded point of speech in the sentence.

The approach of Abusch (1998) comes quite close to the one presented here in that she also treats events, tenses and adverbials semantically on a par, combined essentially intersectively, and arrives at a designated variable treatment of tense. For instance, *John left today* intersects leaving, today, and the past: \( \text{leave} \cap \text{today} \cap \text{then} \rightarrow \text{now} \) while *John will leave tomorrow* intersects leaving, tomorrow and the future: \( \text{leave} \cap \text{tomorrow} \cap \text{t} \rightarrow \text{now} \). Abusch’s question is how to treat simple (finite) tenses embedded in future contexts.

An indexical treatment is not available for the past tense in

> In March, we will discuss the abstracts which were submitted by the end of February. This is a clear case for a relative tense:
> \( \langle \text{submit} \rangle \cap \langle \text{February} \rangle \cap \text{then} \cap \langle \text{now} \rangle \cap \text{discuss} \cap \langle \text{March} \rangle \cap \text{now} \)

i.e. the indexical now is followed by a discussion in March which is preceded by a submission period ending by end of February. The submission period is past relative to the discussion but unordered relative to now. The future past tense is coded by \( \langle \text{now} \rangle \cap \text{then} \cap \langle \text{now} \rangle \). On the other hand again,

Next year, every message which I just placed in this folder will be obsolete.

is a clear case of a free past in a similar context.

Consider next the following sentences:

> Next year, every message I receive which was sent by a friend will be answered.
> Next year, every message I receive which was received from a friend will be answered.

In my analysis, these are a clear case of bound tense. In the first one, the intended reading orders sending, receiving and answering in this order, and places both reception and answer in the indexical future. In my mind, the sentence leaves it open whether *next year* modifies the time of answer or the time of answer. The latter option allows the continuation *eventually*. Another option is whether sending precedes receiving or answering. In the second variant, it must be the latter, for in it, the same reception event is both present and past: the time of *receive* binds the time of *will* whose event time in turn binds *was*. Formally:

\[
\text{send} \cap \text{then} \cap \text{receive} \cap \langle \text{now} \rangle \rightarrow \langle \text{now} \rangle \cap \text{answer} \cap \langle \text{in next year} \rangle \cap \text{now}
\]

The past tense *was* must be a bound tense if *immediately* is added to cancel out the \( < \) before *answer*. The present tense of *receive* must be a bound present because of its closed aspect. Compare

Next year, every message I have which was sent by a friend will be answered.

Here *have* can be free or bound depending on whether *have* is open or closed (meaning *get*). The interpretation of *was* shifts accordingly, which proves it is bound to *have*. It seems hard to make *have* free and *was* bound to *will* at once:

Next year, every message I have now which was resent by a friend will be answered.

The excluded reading has the feel of split perspective: why not simply say *which is/will be resent?*

\[
\text{receive} \cap \text{then} \cap \text{receive} \cap \langle \text{now} \rangle \rightarrow \langle \text{now} \rangle \cap \text{answer} \cap \langle \text{in next year} \rangle \cap \text{now}
\]

That this is a binding problem is confirmed by the acceptability of the following paraphrase:

Next year, every message I have now will be answered if it was resent by a friend.

Compare
We must wear black until the deceased (has) died a year ago.
We must wear black as long as the deceased (has) only died recently.
We must wear black until a year has passed since the deceased died.

The sentences improve going down the list. *Ago* hardly combines with present perfect. As an anchored adverbial it needs a narrative present to associate to. The simple past cannot provide one, for a simple past can denote future only if it is bound to a nonpast event (as in the last example). *Recently* is also anchored, which makes it slightly awkward. Note that the last sentence does not place the death relative to *now*.

Abusch (1988) argues that relative finite tenses only occur in intensional contexts, where *now* points to somebody else’s deictic centre or speech time. (Compare the proof by Kamp (1969) that *now* is redundant in extensional contexts.) If so, future is intensional enough for the purpose:

They will have planted all the roses while you were away. (Smith 1978:54)

This bound future past does not place the absence on the time line any more than its antecedent.

**Past future**

The converse case is even more interesting. English bound present tense can also denote a future time in clauses depending on a future tense:

She will eat it when we get home. *now < eat ∩ home ∩ now2*

His excuse next time will be that he has been ill all week. *now<(week<ill)>excuse*

If you don't say so Bill won't believe that you will help him. *now<believe<help* (Declerck 1994:85)

When this is put in the simple past, the dependent past need not be not past relative to *any* point referred to in the sentence, which makes it hard to construe it a free past.

She promised me she would eat it when we got home. *(promise<now)>eat ∩ home.*

When he told them that he had come back to marry Ginevera, they would go down on their knees to him in gratitude. (Declerck 1994:139)

He said that he should let us know as soon as he (should have/had) heard from them. (Jespersen 1931:§22.9.2)

As conditional paraphrases show, *got* is really a bound *past future* *now>home* dependent on another past future *would eat now>eat*, which entails that its event time is undecided with respect to the indexical *now* (Jespersen 1931:§22.5). In languages which can make the difference, reference to future from inside a past narrative specifically uses past future or conditional forms. Such references to the future are usually embedded in modal or propositional attitude contexts and vague about the relation of the event time with respect to the time of speaking.

*pt* Ela prometiu que com(eri)ja-o (cond) quando ficássemos (subj) à casa.

*fi* Hänen lupasi että sōisi (cond) sen kun palaisimme (cond) kotiin.

‗She promised me she would eat it when we got home.’

This is not an isolated phenomenon. Palmer (1987:§3.2.5.) notes that past future can be bound to another past future in English more generally

You might think he’s/he’d finished it.
I could say I am/was coming.

Abusch (1988) comparing sequence of tense theories (Kamp and Rohrer) to no-sequence of tense theories (Dowty) discusses a well known similar example by Kamp and Rohrer:

John decided a week ago that in ten days at breakfast he would say to his mother that they were having their last meal together.

The point of the example is that seven days back plus ten days forward brings us to the future of now, *so were having* cannot entail *meal<now*. Yet *were having* is a simple past tense. The temporal profile of the example is

*(decide´.(10days.breakfast|say|prog meal)).7days.now*

which shows that the meal is in the scope of the past modality *decided* and the past future *would say*. This places it on a separate branch of history from the actual present. Note that we can’t very well say

John thought he would say they were having the last meal *two days from now*

which once more shows it is not legitimate to substitute extensionally identical indexical references in indirect speech contexts. Clearly what John would say would have to be rephrased, perhaps he would say (in direct speech) *We are having the last meal today, which in indirect speech would go over to on that very day.*
A more grammar true representation of Kamp and Rohrer’s example is

\[
\text{now} \rangle \text{decide} \langle \text{say} \rangle \text{\{prog meal}
\]

In sum, the Kamp and Rohrer \textit{were} is a past future, more precisely, a bound past of a bound present tense \textit{now} \rangle \textit{then} \langle \textit{now}. Here the bound present \textit{now} \rangle is bound to the time of \textit{say} which is future to \textit{then}. The simple past \textit{then} is anaphoric to the event time of \textit{decide}, which is past of the indexical \textit{now}. If we just look at the event time \textit{now} \rangle of \textit{were}, its relation to speech time is a past future: \textit{now} \rangle \langle \textit{now}.

\[
\text{now} \rangle \text{decide} \langle \text{then} \rangle \text{\{say} \langle \text{now} \rangle \rangle \langle \text{now} \rangle \langle \text{then} \rangle \langle \text{now} \rangle
\]

The coincidence of past future and conditional here cannot be a coincidence. My conclusion in the chapter on mood will be that they come to the same thing.

Declerck (1997:98) points out that a bound past can come to the same as a bound past future. The sentences are back shifts of a bound present and a free future, respectively.

She expected he would do it on a day when she herself was absent.

\[
((\text{expect} \langle \text{then} \rangle) \langle \text{do} \rangle \langle \text{day} \rangle \langle \text{when} \rangle \langle \text{absent} \rangle \langle \text{then} \rangle \langle \text{now} \rangle)
\]

She expected he would do it on a day when she herself would be absent.

\[
((\text{expect} \langle \text{then} \rangle) \langle \text{do} \rangle \langle \text{day} \rangle \langle \text{then} \langle \text{when} \rangle \langle \text{absent} \rangle \langle \text{then} \rangle \langle \text{now} \rangle)
\]

Bound past future is a well-known device for narrative perspective. It makes the narrative feel subjective, because the bound tense is counted from the specious now of the narrative (character). The tenses are a back shifted quote from the internal speech of the character.

By the way, the first sentence has another reading in which the simple past \textit{was} is a free past. In that case, the description of the day is de re, as in

She expected he would do it on Sunday, but on Sunday she herself was absent.

\[
((\text{expect} \langle \text{then} \rangle) \langle \text{do} \rangle \langle \text{day} \rangle \langle \text{when} \rangle \langle \text{absent} \rangle \langle \text{then} \rangle \langle \text{now} \rangle)
\]

A present bound to a past future (Declerck 1997:184).

I said that you should have someone close when the time comes.

How would you feel about it if I were to ask you for a date when I get through at Hanover?

**Bound future**

Comrie’s third argument for considering tense shift a syntactic phenomenon was that it is not symmetric around the present. In the future, only quoted and free tenses occur, tense agreement by rule II is missing. Fabricius-Hansen (1989) ascribes the absence of future sequence of tense to the fact that there are no narrative (i.e. anaphoric) future tenses corresponding to narrative past: there is no \textit{then} in the future to hold the time of a future narrative. In the last analysis, this is another case of the asymmetry of time.

Comrie’s \textit{John will say that he will be singing} is a bound future \textit{now} \langle \textit{say} \rangle \langle \textit{sing}. It is not easy to find a clear case of free future in English, but perhaps the following constructed example will do.

She will always resent the fact that the house will be torn down. \textit{resent} \langle \textit{now} \rangle \langle \textit{torn}

This seems to allow that she will resent the fact both before and after it. The indexical reference is easier to get here because the governing verb is factive (\textit{the fact that}… ) which suggests that the embedded future is not properly in the scope of the governing one, but rather the sentence means \textit{The house will be torn down, which fact she will always resent}.

Future \textit{if} clauses normally don’t have \textit{will}. (Reichenbach 1947:298 finds English illogical here.) A rule of \textit{will} deletion was once commonly assumed (Declerck 1994:77, 1997:113). The avoidance of future tense in conditional clauses is not peculiar to English, but a cross-linguistic tendency (Nieuwint 1986, Bybee 1991:19-20). In Irish, the simple (generic) present is used in the antecedent of a future conditional (Baoill 1994:204). Bulgarian too uses simple rather than future tenses here (Lindstedt 1985:74). Portuguese has a special bound mood, conjunctive future (Hundertmark 1982:§8.142).

French has a free future in temporal clauses but not in conditional ones (Vinay and Darbelnet 1958):

Quand il \textit{viendra} il nous \textit{ne trouvera} pas ingrants. ‘When he comes (fut) he will not find us ungrateful.’

S’il \textit{viendra} il nous \textit{ne trouvera} pas ingrants. ‘If he comes (pres) he will not find us ungrateful.’

The free future in the temporal clause above expects the event will actually take place. This indicates that conditional future is specifically at issue here (Jespersen 1924:265). Revealingly, future does appear in English in selected cases.

I’ll die before I’ll do that.

If you’ll do the shopping for me I’ll give you some money. (Comrie 1985:120)
If it will amuse you, I’ll tell you a joke. (Comrie 1986:96).

The will in the before sentence expresses preference: I’ll die before I agree to do that. In the conditional sentence the promise of money is given on the promise of shopping. The future antecedent suggests the money is given before the shopping. This seems to match the contrast between present and future in conditional antecedents in many languages. Thus in Bulgarian (Lindstedt 1985:111)

Ako ste xranis v stola, eto ti menjuto za utre. ‘If you are planning to eat in the canteen, here is tomorrow’s menu.’

In Classical Greek too, indicative future in the antecedent indicates what someone wants or must do: Ei me bothesete, ou periestai takei ‘If you will not help, they will not last’ (Kühner 1896:§573). The contrast in modern Greek goes along similar lines (Hedin 1998): An tha sikothis noris avrio to proi prepi na pas ja ipno tora ‘If you will (want to) wake up early tomorrow morning you have to go to bed now.’

Other modals behave analogously. You may find out you have already won on an advertising letter has, besides the intended nonfactual bound reading, an unlikely factual free one, much more plausible for You may not realise you have been duped. Neither of these is equivalent to You may find out you may have already won. Or compare You may take the car if I take the bike to You may take the car if I may take the bike. The former gives a conditional permission, the latter proposes a deal.

In sum, as Bybee et al. (1991:19) point out, will is a strong (necessity type) modality here, and therefore not what one normally means by a future conditional. A normal future conditional is meant to be detached by any possible future event, not just necessary ones. It is will that is exceptional here (Declerck 1994:88).

Bybee et al. (1994:208,274) argue a modal must become a grammatical (bound) element before it can occur in a protasis without contributing additional meaning. In the latter case, it is interpreted as bound rather than in the scope of the conditional; not as a strong narrow scope operator \( \delta p \rightarrow q \) but as a weak backwards-looking one \( \delta p \rightarrow \sim iq \) (Saarinen 1977). The Portuguese special future conditional mood grammaticalises this operator.

The temporal relationship between antecedent and consequent in a conditional is entirely free. Although causality often suggests the consequent follows the antecedent (If I catch you again you’ll be sorry), this is easily cancelled. A nonpast conditional clause can be future even without an explicit future in the main clause:

If she comes John guessed right.
If anything happens tomorrow, we’ll know about it tonight
If she doesn’t come I have just whitewashed the gate posts for nothing. (Huddleston 1967:803)

Compare also If you come at seven, dinner will soon be ready now\((\text{come}\rightarrow\text{soon, dinner})\), where soon counts from seven and If you leave at seven, dinner will soon be over, now\((\text{leave}\rightarrow\text{soon, dinner})\) where soon counts time from now.

Given that English will has not been grammaticalised to free anaphoric use like the French future, the absence of will from English temporal clauses is even less surprising (Declerck 1997:97, 113).

John will leave before/wait until Mary ?will arrive. <leave<arrive
I will work in the garden till the evening, and then, when it will be cooler, I walk to Blooms-End. (Jespersen 1931:§2.5.3)

The future of an event will arrive \(<\text{arrive}\) has no beginning, and therefore won’t do as a terminus ante quem (see section on eternity). This event type is either empty (if Mary arrives), redundant (if she won’t) or counterfactual (lest she might).

John will leave before Mary will arrive \(<\text{leave}\sim (\text{arrive}) = \sim \text{leave}\).\text{leave}.

The above argument fails in bounded or branching future. There are cases where the main event is really conditional on what will happen (Declerck 1997:169, 185).

Fox shows were promoted when Paramount shows would not be offered.

This system of subsidies will be maintained if the farmers will suffer considerable losses if it is abolished.

The future when in Jespersen's example is a free relative clause: at which time it will be cooler (Jespersen 1931:§16.5). The following example (cf. Declerck 1994:140) is beside the issue. The planning verb invite takes future adverbial complements. The adverb does not time the invitation, but the appointment.

John invited Mary tomorrow at six / when he would be away.
**Sequence of tense as agreement**

Ritchie (1979) proposes a *surface tense constraint*: If two clauses are joined by a temporal connective, they must both have the same (finite) tense. There are counterexamples.

I have once given him money when he asked.

The cases correctly excluded by Ritchie’s constraint can also be explained without it.

I always give him money when he asked.
I always gave him money when he asks.
I had mailed the letter when John has come. (Hamann 1987:35)

The bad combinations are empty given *then* <now>. The good combinations are not: If the subordinate tenses are free the bad combinations are excluded too.

\[
\text{ask} \cap \text{then} <\text{now} \rightarrow \text{give} \cap <\text{now} \quad \text{‘I always give him money when he asked.’}
\]

\[
\text{ask} <\text{now} \rightarrow \text{give} \cap \text{then} <\text{now} \quad \text{‘I always gave him money when he asks.’}
\]

\[
\text{come} \cap <\text{now} \cap \text{mail} \cap \text{then} <\text{now} \quad \text{‘I had mailed the letter when John has come.’}
\]

\[
\text{ask} \rightarrow \text{give} \cap <\text{now} \quad \text{‘I always give him money when he asks.’}
\]

\[
\text{ask} \cap <\text{now} \rightarrow \text{give} \cap \text{then} <\text{now} \quad \text{‘I have always given him money when he asks.’}
\]

\[
\text{come} \cap \text{then} <\text{now} \rightarrow \text{give} \quad \text{‘I always gave him money when he asked.’}
\]

Although the anaphoric past *then* <now> takes its reference time from the main clause, it remains a past tense (it satisfies *then* <now>). What is more, there is a sense in which the dependent present <now> turns out to remain a present as well. That is apparent when we invert the scopes of the tense and the conditional. When *he asks* then denotes a disconnected extended now which is covered by matching sequence of giving.

\[
(\text{ask} \cap \text{then} <\text{now}) \cap <\text{now} \quad \text{‘I have always given him money when he asks.’}
\]

which makes the dependent present <now> denote an extended now, i.e. it satisfies <now>. This bears comparison to the Romance use of present (perfect) with *il y a/há t que V*.

The general insight here is that tense agreement can be construed as distribution of tenses into an event type, i.e. as an operator inversion. Consider for instance

He has always lived in his own house \(\text{live in x:house} \cap \text{own x} \cap <\text{now} = <\text{now}\)

This has one perfect tense. What it means is approximated by the event type on the right: the past is covered by the event type of living in one’s own house. It can also be approximated by the following two sentences with two tenses:

He has always lived in a house which he owned. \(<\text{now} \subseteq \text{live in x:house} \cap \text{own x} \cap \text{then} \cap <\text{now}\)

He has always lived in a house which he has owned \(<\text{now} \subseteq \text{live in x:house} <\text{now} \cap \text{own x} \cap <\text{now}\)

These sentences may also have readings where the scope of *always* is narrower. For instance, the following do not entail that he has always lived somewhere.

He has always lived in a house which he owned. \(\text{live in x:house} <\text{then} <\text{now} \rightarrow \text{own x:house} \cap \text{then} = 1\)

He has always lived in a house which he has owned \(\text{live in x} <\text{now} \subseteq \text{own x:house} <\text{now}\)

Finally, in the following variant, the noun phrase has been multiplied out entirely.

When he has lived in a house he has owned it. \(\text{live in x:house} <\text{now} \subseteq \text{own x} <\text{now}\)

When he has owned a house he has lived in it. \(\text{own x:house} <\text{now} \subseteq \text{live in x} <\text{now}\)

When he has lived somewhere it has been a house he has owned. \(\text{live in x} <\text{now} \subseteq \text{own x:house} <\text{now}\)

Compare the section on sequence of aspect.

**Mixing tenses**

It is not necessary to have a grammatical rule against mixed tenses, if they simply don’t say what we want to say. Consider

Christ promised that he will/would return soon.

Given the meaning of the English present tense, *will* refers to a future of now. If we want to report what He actually said, we have to use *would*.

Individual tenses may be free (indexical) or bound (Declerck 1997). Dowty (1982) supposes that a past future *would* is always bound. This is nearly true. As noted earlier, a past future has an edge over a simple tense only if using it makes a
difference, either perspectival or modal. A main clause \textit{would} therefore always appears modal: \textit{Last year he would do/have done it, but today he won’t.} Dowty also feels that used to in Algernon figured he used to be Rhesus negative is bound to be past relative to figured. A counterexample would place the habit in the past of now but leave its relation to the governing verb indeterminate. Perhaps Algernon never found out he used to be Rhesus negative is such an example. It seems to profess ignorance of the (now past) disposition not only after, but also during and before the fact. Note the difference: what Algernon did \textit{not} figure out cannot be a quote of Algernon’s belief. A related point is that a belief is caused by something, and effects do not precede causes.

This is related to Dowty’s claim that \textit{John believed that Bill was here} cannot place John’s belief before Bill’s presence. This too seems nearly true: if we are reporting what John believed (in his own words), we should say \textit{John believed that Bill would be here.} But the same grammatical configuration with a negative verb and a factual complement allows the subordinate tense to be indexical rather than bound: \textit{John never found out who succeeded him.} A similar contrast between \textit{verba dicendi et sentiendi} and factual complement constructions is clear in Dowty’s pair

\begin{quote}
One day John will regret that he is treating me like this.
Smith will claim on the witness stand that he is in Mexico.
\end{quote}

The first sentence (with the factitive verb \textit{regret}) has an indexical present. The second sentence (with a \textit{verbum dicendi}) is purported to describe the future defense of a criminal now in Mexico. It is very curious unless the tense is changed to the past (to reflect the wording Smith \textit{will} use). For further confirmation, note that the second sentence is saved by replacing \textit{claim on the witness stand} with \textit{exploit the fact}.

\section*{Split perspective}

The successes so far suggest that no separate sequence of tense rule is needed. Illicit out of sequence combinations are simply inconsistent.

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Tense</th>
</tr>
</thead>
<tbody>
<tr>
<td>John ate breakfast after he leaves. now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>John will leave before he ate breakfast. now&lt;\text{leave}&lt;\text{breakfast}&lt;\text{now}</td>
<td></td>
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</tbody>
</table>

These sentences are clearly inconsistent on the indicated readings. But what should be said about the opposite batch:

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Tense</th>
</tr>
</thead>
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<tr>
<td>John ate breakfast before he leaves. \text{eat}&lt;\text{now}&lt;\text{leave}</td>
<td></td>
</tr>
<tr>
<td>After Mary left, Bill will leave. (Parsons 1990:227) now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>The train is leaving after Mary arrived yesterday. (Huddleston 1967:791) now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>Mary likes Bill after he brought her flowers. now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>John left before Lucy comes. Lucy will come after John left. (Heinämaki 1974) now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>I helped John when he has been in trouble. (Declerck 1997:134) now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>Peter said he would leave after John returns. (Huddleston 1967:793) now&lt;\text{leave}&lt;\text{eat}&lt;\text{now}</td>
<td></td>
</tr>
</tbody>
</table>

The second sentence gets better with \textit{now that} instead of \textit{after}. Some sentences are fine when the conjunction is nontemporal (Ritchie 1979). Heinämaki (1974:75) points out that tenseless forms are ok too: \textit{John ate breakfast before leaving}.

These sentences are certainly redundant given the former are inconsistent (Heinämaki 1974:74). But is that enough to explain them away? Redundancy is usually not enough to make a form ungrammatical. My suggestion is that the examples \textit{are} inconsistent, for the tense constrains the denotation of the entire adverbial clause, so that \textit{after he arrived} denotes a proper past \textit{arrive} \textless now and before he leaves a nonpast period \textit{now} \textless= \textit{leave}.

<table>
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<tr>
<td>John ate breakfast before he leaves. now\textless=\textit{leave}\textless=\textit{eat}&lt;\text{now}</td>
<td></td>
</tr>
<tr>
<td>John will leave before he ate breakfast. breakfast\textless\textit{now}\textless=\textit{leave}</td>
<td></td>
</tr>
</tbody>
</table>

Rohrer (1977:10) feels \textit{after} cannot replace \textit{(ever) since} in the following sentence:

\begin{quote}
Ever since Mary left, John has been crying.
\end{quote}

Actually, an existential reading is possible where the crying is properly past:

\begin{quote}
John has been crying after Mary left.
\end{quote}

Rohrer’s observation agrees with the idea that \textit{after Mary left} is a loose (proper) past time adverbial like \textit{recently}. This makes our second batch of out of sequence sentences above inconsistent, not just redundant.

\textsuperscript{144}The second sentence also has a consistent reading where \textit{ate} is a future past equivalent to \textit{has eaten}. 
Note that though both of *Mary promised to talk to Bill before she left* and *Mary promised to talk to Bill as soon as he arrives* are good, their meet has a disjointed reading where Mary and Bill miss one another.

Mary promised to talk to Bill before she left as soon as he arrives.

The consistent reading is better brought out with before she’d leave as soon as he’d arrive.

Compare finally

It is a good thing that I did not leave before you came. \( \text{not (leave<come<now)} \)

It is a good thing that you came before I left. \( \text{now>come<leave<now} \)

The two sentences say practically the same thing. The after sentence naturally has past tense throughout. The past tense of the before sentence is a counterfactual past future rather than just past; it can be rephrased with *would have left* (I have not left yet - I may not leave at all now).

A way of rephrasing the error is to note that though consistent, the subordinate and main clauses denote different events. *John ate breakfast* denotes a past event, *before he leaves* denotes a nonpast one. There are sentences with indexical adverbials which are also temporally consistent but have a split perspective, i.e. there are more than one point of view from which temporal references must be reckoned.

The milkman knew last week that he would come yesterday. \( \text{last week} \cap \text{know} \cap \text{then<now} \cap \text{then<come} \cap \text{yesterday<now} \)

John will say later that he arrived tomorrow. (Comrie 1985:113) \( \text{now<say>arrive\cap tomorrow>now} \)

In the first example, *would* is a dependent tense attributed to the milkman then, which conflicts with the indexical reference to *now* of yesterday. A sentence should have a consistent point of view, i.e denote one fixed *now*, not two events at the same time. Violations resemble the failure of substitution of factual equivalents in propositional attitude contexts. Cases of split perspective have the same feel: he would come yesterday is funny because it does not consistently represent the milkman’s nor the narrator's propositional attitudes. Cf. temporal congruency in Klein (1994:166). See Carlson (1988) for cases of split perspective in the nominal domain.

The event type of *I helped John when he has been in trouble* \( \text{help<now} \cap \text{when\cap trouble<now} \) is empty, for the proper past help cannot match the extended now of the troubles.

Declerck (1997:127) points out the following contrasts.

\begin{align*}
\text{John will leave when the others leave / have left.} \\
\text{John will leave because the others (will) leave / (will) (have) left.}
\end{align*}

*When* only suffers present and perfect. The tense of the *when* clause must be bound, for the closed event type when cannot denote *now* (see section on when). Disregarding *when*, the event types will be \( <(\text{John} \cap \text{others})> \) for the present tense and \( <(\text{John} \cap \text{others}:<\text{John})> \) for the perfect. Why not

\begin{align*}
\text{John will leave when the others will leave} \\
\text{John will leave when the others left}
\end{align*}

Free readings are again excluded by *when*, and can be brought back with *now that*. A bound future \( \text{will leave }<\text{others} \) in *now<.(John<.others)* is a bad timer because it is unbounded to the left (recall section on boundedness). It can be improved by interpreting *will* as a modal (*want* to leave) or by replacing *will* with a bound near future *are about/going to* (Declerck 1997:126). As for the simple past sentence, a free simple past \( \text{now<.(John<.others<now)} \) denotes nothing. So does a bound simple past \( \text{now<.(John<.others<.John)} \). One cannot leave when one has left.

The *because* clause allows all combinations. All tenses in it can be free or bound. The present past and perfect denote slightly different event types, \( \text{now<.(John because others<John)} \) and \( \text{now<.(John because others<John)} \), respectively. For the simple past, the reason was the departure, for the perfect, it is the absence. In each case *because* can give my reason, or John’s, the bound tenses more readily John’s. Discourse uses of *when* are also free about tenses (Declerck 1997:§11.9).

Sequence of tense as event consistency predicts that all bets are off when tenses are not related to the same event. The following consistent event types are in no way exceptional (Declerck 1997:182,§11).

I had reached the age when sexual questions pester the imagination.

Dag Hammarskjöld’s death came at a moment when peace hangs precariously.

At the time this history commences, Robert Moore had lived but two years in the district.
Grammaticalisation of tense

Operator distribution is what happens in grammaticisation of tenses as well. Declerck (1997), calls this a contrast between present and future perspective systems. The present perspective system has bound present, the future perspective free future (Declerck/Depraetere 1995). In English, the (in)dependence of the tense correlates with that of a relative or conditional clause.

I will ask somebody who knows the answer then. \(<\text{ask\{know\}}\) then
I will ask John, who will know (?knows) the answer then. \(<\text{ask then}\)\{<\text{know then}\}

Future perspective is where future has been grammaticalised. For compare

You will be met by a man. He is wearing a red tie. \(\text{now}<\text{meet}\{\text{then}\} \land \text{now}<\text{wear}\{\text{then}\}\)
You will be met by a man who is wearing a red tie. \(\text{now}<\langle\text{meet}\{\text{wear}\}\rangle\)
You will be met by a man. He will be wearing a red tie. \(\text{now}<\langle\text{meet\{then\}}\rangle \land \text{now}<\text{wear\{then\}}\)
You will be met by a man (\(\cdot\)) who will be wearing a red tie. \(\text{now}<\langle\text{meet\{\text{now}<\text{wear}\}}\rangle\)

The first text has an explicit future in the first sentence and an unmarked extended present tense in the second. Kiparsky (19??) has suggested that this sort of arrangement obtained in Proto-Indo-European. The next two examples exhibit the current situation in English (Declerck 1997:87) where we have a bound present inside and a free future outside a construction, respectively. The last example has a free future inside a relative clause. In English it tends to get interpreted as an iterated (bound) future (meaning the man will wear a tie after the meeting). Not so in a language with a grammaticalised future. (Compare section on bound future.)

Note what grammaticalisation of the future tense entails here:

(i) it distributes so it appears as agreement
(ii) it becomes a grammatical accident so it is marked everywhere
(iii) it becomes redundant (it is redundant in the last formula above)
(iv) it becomes background (it is entailed but not denoted in the last formula above)
(v) it becomes free (indexical).

All of these points are cited in the grammaticalisation literature. The only new feature is that the formalisation makes algebraic sense of the lot, explaining also why they go together. Compare section on logic of grammaticalisation.

English sequence of tenses

The account of the distributional facts so far does not exclude bound simple past under (finite) present. In fact, three tenses are possible.

I have always gone to bed when I (have) want(ed to). \(\text{want\{then\}}<\text{now} \rightarrow \text{bed\{r\}}<\text{now}\)

Recall also

John will say tomorrow night that he was singing in the morning. (Comrie 1985)
He will trip you on purpose and say it was an accident.
Mrs. Dalloway will murmur that the party had been a success. (Smith 1978:54)
They will have planted all the roses while you were away. (Smith 1978:54)

Examples of this sort belie an agreement rule for past tense in the style of

Only a (finite) past tense can bind a (finite) past tense.

As Abusch (1988) noted, simple past gets more easily bound by present in intensional (indirect, quoted) contexts than in extensional (direct) ones. Compare

The Commission never reveals which projects got bad reviews.
The projects which got bad reviews never make the short list.

The real reason may lie deeper. To bind a definite past, a mapping must be contextually provided from the independent tense to the dependent one. In an intensional context, a mapping is assumed given through causality (knowledge by acquaintance). When a contextual mapping is provided, binding gets better in the extensional case as well:

Whenever there is a review, the projects which get bad marks don’t make the short list.
Whenever there has been a review, the projects which got bad marks don’t make the short list.

It seems to me that a simple past got is better with an antecedent perfect \(\text{has been}\).

The valid part of English sequence of tense so far can be summed up by the following constraint on relative tense:
A (finite) present tense is free inside a (finite) past tense.

In other words, English (as a rule) does not apply Fabricius-Hansen’s quoting rule I in the past. This is the sound core of Comrie’s point that sequence of tense is a rule of grammar of English.

**Bulgarian sequence of tenses**

The apparent lack or optionality of sequence of tense in Bulgarian described in Lindstedt (1985:88ff) is largely due to Bulgarian use of the quoting rule I, which allows bound nonpast tenses in past tensed sentences. Thus the Bulgarian sentence glossed *The old composer knew that he will soon die* is tantamount to the English *would die*, i.e. he may or may not be dead now. This use of nonpast tenses only occurs in the complements of *verba dicendi et sentiendi*. One might say that a Bulgarian nonpast tense refers to a narrative *now* equal to an English narrative *then*: die\(\begin{array}{c}\text{now}2\end{array}\)know\(\begin{array}{c}\text{then}\end{array}\).

In Lindstedt’s (1985) sequence of tense rule for Bulgarian, the indexical reference point of any tense can be replaced by a contextually supplied past one. With this, he intends to subsume the quoting use of nonpast tenses above under one and the same rule with occasional uses of simple past tenses which seem to allow an anterior reading in past contexts. A weakness in this supposition, which Lindstedt points out, is that the latter phenomenon is more sporadic than the former. In addition, the latter is not found in reported contexts, where the former appears. Comparing to similar cases in English, Greek, Russian or Portuguese (quod vide), some of the cases be free pasts short-circuiting the pluperfect. Others may be indeed be colloquial quoted simple pasts, cf. English examples in the section on English sequence of tense. For the Bulgarian situation, see section on Bulgarian reported tenses.

**Sequence of aspects**

Aspect in subordinate clauses presents behavior that resembles agreement. In English, we have something resembling sequence of aspect in perfect sentences like Palmer’s (1987:§4.5)

He’s always said he’s (been) willing.

This can be treated compositionally as a choice between bound present and indexical perfect. A clearer case is this. When a closed subordinate clause is in the scope of an iteration, Russian prefers the perfective, Portuguese the imperfective. (Of course, both can have imperfective if the events are open.)

- **ru** Soldaty … breli po mertvym zabelevshim ravninam. Kto upal - ne podnimalsja. ‘The soldiers wandered on the dead white plains. Whoever fell (pf) did not get up (ipf).’
- **ru** Kogda chelovek konchit kakuju-libo rabotu, on bystro o nej zabvyajet. ‘When one finishes (pf) some work or other, one soon forgets (ipf) about it.’
- **ru** Kogda voda zakipajet/zakipit, zapuskajut rybu. ‘When the water is boiling (ipf) /comes to a boil (pf), the fish is dropped (ipf) in.’
- **pt** Quando passava pelo sono sonhava com fantasmas horríveis, com a morte do cura, ou até mesmo com jantares sumptuosos. ‘When he fell asleep for a moment (ipf) he had awful nightmares (ipf)’ - back translation, Wells: War of the Worlds

- **pt** Quando as dores o assaltavam, gemia e exclamava… ‘When the pains assaulted (ipf) him, he would sigh (ipf) and exclaim (ipf)… O Egipcio XIII

The Russian subordinate perfective aspect is in the scope of the iteration as indicated by *ipf (e when b)*: each individual dependent event is closed, but the entire iteration is open. This must be a case of scope, for there is no way to treat the perfective and the imperfective as independent yet simultaneous. The objective situation is the same in Portuguese, but the dependent aspect is imperfective. A perfective *passou* in Portuguese would not stay in the scope of the imperfective, but yields *ipf e when pf b*: when he (once) passed into sleep, he was having nightmares (then). This is another index of grammaticalisation of Portuguese aspect.

In English, *I used to drink a lot after I used to run* is odd (compared to *I used to drink a lot when I used to run*). If one means that there was a habit of drinking after running, one has to say *I used to drink a lot after I ran*. If one means the habit of running was over before I took up drinking, one has to say *I used to drink a lot after I quit running*.

There are at least two approaches to treating the apparent agreement in Portuguese. A morphological alternative is a rule which distributes the imperfective aspect of the governing iteration over the subordinate clause like some kind of plural agreement. The semantic alternative is to claim the imperfectives in Portuguese are really independent and compositional.

The situation resembles number agreement. English has a *number* agreement constraint missing from Finnish: English *The ladies had hats on their heads* is in Finnish *Naisilla oli hattu päissä* 'The ladies had a hat on the head' (not plural *hattat päissät*, which would mean the ladies wore hats on both ends).

Now compare
The president shook hands with the ladies before he greeted their spouses. This could describe a situation where the president went through all the ladies first. But it can also describe a situation where mixed couples passed the president in a long line. It seems that plural before/after sentences do not specify a particular order, but are consistent with many. There is considerable vagueness about what it means for one disconnected event type to precede another (see section on order of intervals). Compare

The finches migrate to Finland before the swallows.

Does this mean every finch migrates to Finland before every swallow? Does it imply the first bird to come is a finch and the last one is a swallow? Or that most finches arrive before most swallows? It can just mean that if you look at the migration chart, the fuzzy blot representing the finches is a little to the left of the blot representing the swallows: The average fink is in Finland before the average swallow. (Or perhaps it is the median fink.)

Now back to the aspect problem. If we take the main and subordinate clauses to denote two disconnected events, then individual events within the iterations do get paired up by just covering the same disconnected stretch. In general, there are several scenarios open for ordering the individual events, as is seen from the president example.

The following is an example of iteration of a sequence of events in Russian, where the intended reading is (e₁…eₙ)⁺ and not e₁⁺…eₙ⁺ i.e. a sequence of events iterated, not a sequence of iterated events.

ru Dal’she vse poshlo po-zavedennomu. Odin za drugim podnimalis’ na tribunu oratory, optivali vody iz stakana i proiznosili rechi. ‘Later on, everything went as usual: one after another speakers got up (ipf) on to the platform, drank (ipf) some water from the glass and made (ipf) speeches.

Does this show that the imperfective aspect operator distributes over a discourse here? Not necessarily. A more plausible alternative is that the discourse is just vague. Iterated events are freely ordered as far as aspect semantics goes, and it is the adverb odin za drugim ‘one after another’ plus world knowledge that order the events. What looks like aspect agreement is just generic reference.

Tense anaphora

Following this school, I do not treat reference time as an index or point of reference in the sense of modal logic or intensional pragmatics or , i.e. as a shared global variable defining a local view of the evaluation situation which successive sentences relate to or shift. I prefer to take a global view, treating reference times as values of local variables associated to each tense individually. The metaphor of shifting reference time only means shift of attention from one reference time to another as a discourse is taken in. It is no different from shifting attention from one character to another in the plot with changes of subject. The referent of each tense (its reference time) is located in a complex discourse context in ways not essentially different from choosing referents for (pro)nominal expressions. There is a number of putative referents in evidence in the surrounding discourse, and further ones can be inferred. There is no mechanism for tense anaphora or reference time shift, rather, temporal reference resolution is part (and parcel) of reconstructing the logic of a dialogue, using tenses and aspects as constraints on possible interpretations. For more data see the sections on discourse and on English tenses.

Present
Smith (1980:358-60)) points out the following phenomenon.

Scott can’t come to the picnic tomorrow. He is busy.

The simple present can be taken to extend to the time of the picnic (he is busy tomorrow too). .

Simple past
The reference time of a simple past may or may not be constrained by a preceding adverbial. Time is all up for grabs, there are no grammatical rules here. The reference time need not be mentioned anywhere, it may be interpolated from what is said and understood (Vet 1993:230, Molendijk 1996:113). Consistency and coherence of the reconstructed dialogue game rules.

McCawley (1971) notes that last night seems misplaced in the lower clause if it is to serve as antecedent for the main clause tense. The main clause position is preferable in

Max couldn’t sleep although he was tired last night.
Max couldn’t sleep last night although he was tired.

Similarly, in the following example a simple past gets its reference time from another past event, not the adverbial:

Did you go downtown yesterday? Did you buy anything?

town\yesterday\then ∧ buy\then

The second past is likely to refer to when you went downtown, not anytime yesterday: repeating yesterday in the second sentence would change the meaning.

In the last forty years he wrote many letters, essays, and treatises, on various subjects; some of which he printed in separate volumes; others he published in magazines; a few appeared in newspapers, but he destroyed, by far, the greatest part of them.

Here we cannot avoid deducing that everything happened within the last forty years. Changing last forty years to his first forty years cancels this inference.

Jean se mit en route dans sa nouvelle Mercedes. Il attrapa une contravention. Il roulait trop vite. ’

¬drive.drive∧ticket∧speed≤ticket

From the speeding ticket script we can infer that the time of the speeding must fall between hitting the road and the ticket. (Moelendijk 1994, Berthonneau/Kleiber 1994). Other scripts work for

Jean se réveilla à 8 heures. Il dormait bien. ’Jean woke up at eight. He slept/was sleeping well.’

sleep.¬sleep\8h\then ∧ prog sleep\then

sleep.¬sleep\8h\then ∧ pf sleep\then

The first says he was sleeping well when he woke up. Pourtant or Quel pitie! fit this reading. The second says Jean habitually slept well, including then. A pluperfect allows a more natural storyline here:

Jean se réveilla à 8 heures. Il avait bien dormi. ’Jean woke up at eight. He had slept well.’

sleep.¬sleep\8h\then ∧ sleep then

There is a difference in voice between the two stories (Genette 1970): only the latter story is able to follow Jean’s own stream of consciousness

The event time of an anaphoric past is not necessarily mentioned within in the same sentence; the reference may come from outside the sentence (Smith 1978:64).

**Present perfect**

Can perfect be anaphoric? It is customary to say with Lindstedt (1985:85) that the perfect cannot be used to tell a story: it does not advance the plot of the narrative.\(^{145}\) Vlach (1993:271) presents an argument showing that the extended now of the present perfect can be anaphoric. Compare

Bill (has) arrived, but Mary did not talk to him.

Bill (has) arrived, but Mary has not talked to him.

In the first pair, Mary did not talk to Bill when he arrived. In the second pair, Mary has not talked to Bill since he arrived (she may have talked to him earlier occasions). Of course the anaphoric constraint is not obligatory, but it is certainly plausible. What people mean by saying that the perfect is indefinite is that the event time of the perfect is not fixed within its reference time.

Bill has arrived this morning, and Mary has talked to him (now).

Bill arrived this morning, and Mary talked to him (then).

The extended now leaves it open just when the events took place. In the corresponding simple past sentence event time is unique within reference time, so coreferential simple past events are implied to have occurred around the same time.\(^{146}\) In both cases, it is the reference times that match.

I’ve tried to call my brother today, but the phone was busy (then)/has been busy (all day).

\(^{145}\)Lindstedt (1985:85 fn 18) notes that evidential perfects can carry on a narrative.

\(^{146}\)Vlach notes that Bill has arrived, but Mary did not talk to him is a little odd. In my opinion, the problem is that the conjoined clauses talk about two different times. This difficulty is alleviated by adding the premise Mary promised to talk to Bill before she left / as soon as he arrives.
I’ve cut my hand! - Well, where did you cut it (then) / have you cut it (now)?

Lindstedt (1985:85) compares the difference in definiteness between the perfect and the simple past to a scope difference in

All those who have taken somebody else’s property will be punished.
All those who took somebody else’s property will be punished.

The perfect suggests the scoping ‘each person for whom there is a theft committed by him will be punished’, the simple past the opposite scoping ‘there is a series of past thefts such that all those who were involved in them will be punished.’ Looking more closely, the scope argument is not compelling. The present perfect just allows the thefts to extend until now, while the simple past restricts them to a proper past period. The suggested scoping is one way to satisfy this requirement.

Consequently, the most typical use of sustained present perfect is a temporally unordered list (McCoard 1978:55):

He has called in question, in a most downright manner, the genius of such men as Ibsen and Strindberg. He has assailed with the vilest abuse such unassailable names as Mr. Joad and Mr. Aldous Huxley. He has laughed loudly and rudely at Mr. Galsworthy and Sir James Barrie.

It is possible to transpose a narrative into a present perfect description of a habitual course of events.

I was waked up in the morning by the cat wanting to be fed. I did not get up at once, but eventually, I had to give in. I pushed the cat away from my face, went down to the basement, and shedded some cat food in his cup. I filled his water cup with fresh water. After his breakfast, I let him out and went back to bed.

Every morning in recent years, I have been waked up in the morning by the cat wanting to be fed. I have not always got up at once, but eventually, I have had to give in. I have pushed the cat away from my face, gone down to the basement, and shedded some cat food in his cup. If necessary, I have filled his water cup with fresh water. After his breakfast, I have let him out and gone back to bed.

A temporal adverbial can match the event time of a perfect or its reference time. As Declerck (1997:88) notices, the difference shows in bound tense.

John will have left when Bill arrived. now<(when\(arrive\)\(leave\)<now2)
John will have left when Bill arrives. now<(leave<when\(arrive\)\(now2)

If Bill’s arrival happens at the same juncture as John’s departure, the latter is past when the former is completed. Neither event can be placed relative to now. In the second case, Bill’s arrival is a terminus post quem for John’s departure. The arrival is still upcoming, the departure can be any time.

Pluperfect

A pluperfect is by school grammars the simple past of the perfect or the simple past of the simple past. On the basis of extended flashbacks, Eberle and Kasper (1994:158) argue that the interpretation of pluperfect requires distinguishing two reference times, what they call reference point and temporal perspective point. The reason is that a string of pluperfects in an extended flashback can exhibit narrative progression, which in their analysis means the event time of a previous pluperfect is the reference time (reference point) of a subsequent one:

Alain arriva au sommet vers midi. Il s’était levé à cinq heures et demie, avait préparé son lunch, s’était mis en route et avait passé la station de base avant sept heures. ‘Alain reached the top around noon. He had got up at five thirty, had fixed lunch, had set out and passed the base station around seven.’

Here is an English example from Dashiel Hammet (Cowper-Kuhlen 1987:24):

While we were talking about it, a pair of plain-clothes men brought in the red-faced bird who had stopped the slug I had missed Whisper with. It had broken a rib for him, and he had taken a back-door sneak while the rest of us were busy. Noonan’s men had picked him up in a doctor’s office. (Hammett, Red Harvest)

I do not think this phenomenon needs additional semantic machinery. The habitual perfect narrative already shows that narrative progression can be reconstructed without explicit support from tense semantics. The following example shows that a sequence of explanatory sentences can run through a course of events in reverse (Steube 1988:214). The reference times of the past perfects all point to the time when Peter’s progress was stopped and the reasons for it became apparent.

Nach der letzten Prüfung entschloss sich Peter, ins Kino zu gehen. Am Neumarkt wurde er nicht durchgelassen. Die Keller waren voll Wasser gelaufen. Es hatte ein starkes Gewitter gegeben. Das hatte Peter in dem fensterlosen Prüfungsraum gar nicht gemerkt. ‘After the last exam, Peter decided to go to the cinema.
On Neumarkt he was not allowed through. The basements had been flooded with water. There had been a heavy thunderstorm. Peter had not noticed that at all in the windowless exam room.’

Declerck (1997) calls pluperfect a relative tense on the grounds that its reference time must be related to, or bound by, another time in the discourse. That this is the case is not quite obvious in examples like Jespersen’s

We had hoped he would recover. (Jespersen 1954:84)

where the reference time is reverse engineered from an implicature of the same sentence. The reference time of Did you know Bill is sick? is figured out in the same way.

A contrast between a free vs. a bound explanation is apparent in the French option between imparfait and pluperfect in

Il rattrapa un contravention. Il roulait/avait roulé trop vite. 'He got a ticket. He drove / had driven too fast.'
(Irandoust 1994:77)

¬ticket.ticket
∪then<now ∧ speed
∪then<now / speed<then<now

Future
The low degree of grammaticalisation of the future tense in English was seen in the absence of free anaphoric future (sequence of tense) in intrasentential anaphora, particularly in intensional (indirect speech) contexts. The natural transposition of the first sentence into future in English is the second one, not the third.

When she saw him, she did not believe that he was the man she wanted.
When she sees him, she will not believe that he is the man she wants.
When she will see him, she will not believe that he will be the man she will want.

Languages like French with a more grammaticalised future tense exhibit sequence of tense in some of these contexts. These problems naturally disappear in discourse:

She will see him. He will not be a man, or she will not want him, at least she will not believe so.

Abusch (1998:29) points out that a discourse like

Mary will visit London next year. John will be in Ohio.

has a reading where John is in Ohio at the time of Mary's visit. But it also has a “reading” where John is in Ohio next year at another time, and a reading where there is no connection. No particular machinery is needed to distinguish the cases.

Aspect anaphora?
Vlach argues that temporal anaphora extends to aspect as well. His argument is that a simple sentence like He mowed the lawn can answer What did Max do in the yard this morning? as well as What did Max do regularly during the summer? The point is that for the second sentence to answer the question, it is not enough to match reference times, the aspects must also match. I would rather turn the analogy around: anaphora (inference of identities on the basis of coherence assumptions) is a special case of inference. In order to satisfy a question, an answer must entail the question (Carlson 1983), which suffices to select the requisite reading.

Tense combinatorics
Hinrichs (1986) charts the problems of temporal anaphora in terms of a list of nine logically possible combinations of tenses, adverbs and conjunctions. Here are my analyses of his examples with comments.

Temporal Adverb - Tense Morpheme:
Sheila had a party last Friday and Sam got drunk. party
∪then1 in Friday∧drunk
∪then2<now.
Semantics leaves open the time of getting drunk. One likely relation on the basis of world knowledge is then2<then1, but others are possible, e.g. a list answer to What happened last week?

Temporal Conjunction - Tense Morpheme:
When Susan walked in, Peter left. enter<when∧leave<now.
Peter leaves as a consequence of Susan’s walking in. This sequential reading has been discussed in the section on when.

Tense Morpheme - Tense Morpheme:
He took off his clothes, went into the bathroom, took a shower and went to bed. clothes.bathroom.shower.bed<now
The sequence of events is supported by (i) event type: clothes→clothes is closed (ii) tense: simple past then<now requires a definite past reference times. (iii) world knowledge: shower↔bathroom, bed↔bathroom (iv) narrative topic structure And what happened then? (v) iconicity.

_Tense Morpheme - Temporal Adverb:_

They wheeled me into the operating room and put me under sedation. Three hours later I woke up. surgery.sedation.3h.wake<now.

_Three hours later_ is an anchored time adverb with the logical form t.3h<.

_Temporal Adverb - Temporal Adverb:_

This week I toured London. On Thursday I saw the Tower. London|week<now<then1<now A Thursday<then1<then2<now. On Thursday is a definite calendar adverb which requires a definite week. Given Tower is a London sight, this week provides a plausible context, giving Thursday this week. (Compare Last week I toured London. On Thursday I saw Edinburgh.)

_Temporal Adverb - Temporal Conjunction:_

Last Saturday when the State Fair started, all hotels in town were booked. Saturday|when|fair booked. This is a straightforward intersection of time adverbials.

_Tense Morpheme - Temporal Conjunction:_

They ordered two Italian salads and a bottle of Frascati. When the waiter brought the wine, they noticed that they had forgotten their checkbook. order.bring|when|notice|forget<

The sequence is supported by lexical relations (order/bring), nominal anaphora and the restaurant script. Tenses and adverbs have little say.

_Temporal Conjunction - Temporal Conjunction:_

When all the cars poured out of the parking lot after the concert was over, a big traffic jam developed. concert>over<out|when|jam. Syntactically, after and when can be coordinated or nested. Semantically, that makes no difference, for the adverbial clauses are intersective.

_Temporal Conjunction - Temporal Adverb:_

When Melissa left the party, Bill left five minutes later. Melissa<when|5min>Bill. This assumes that the anchored adverbial five minutes later t.3h< is anchored to Melissa left. (Instead of, say, usual).

_Tense and scope:_


All seedlings will become trees.
An old man was born here.
Every fugitive is now in jail.

This could speak of some specific seedlings now (the) or of any past, present, or future seedlings. The man was not old when he was born, and the jailed fugitives are no longer fugitives. My impression is that there is not much structure to this phenomenon. The ambiguities are there, but few dependencies between syntactic configurations and admissible domains of discourse in tensed contexts. In general, a scope account tends to predict too many readings (Ladusaw 1977, Dowty 1982, Musan 1997).

One putative phenomenon is the existential implicature on the subject in perfect sentences (Hoepelman/Rohrer 1981):

Beethoven has already composed five symphonies.

Especially the _already_ strongly suggests Beethoven exists at the moment of speaking. The suggestion can be explained without recourse to scope, however. The perfect denotes an extended now. _Already_ (quod vide) means by now, which implicates composing has continued until now. Composing is done by living people, ergo, Beethoven must be alive. (See section on existence entailments below.)

_Tense does interact with scope in cases like Abusch’s (1988)_
John suspected that the man who killed him/would kill him was behind the door.

If the reference is attributed to John, the tense must be bound; if the tense is free, the reference must be the speaker’s.

**Time in discourse**

In the pragmatic turn of the eighties, it became felt that a sentence based truth conditional approach to tense and aspect was insufficient or even misguided (Hopper 1982, Thelin 1990). It was emphasized that tense and aspect create and reflect discourse structure (Leinonen 1982, DeLancey 1982). More global concepts of structural rather than truth conditional definition were brought into play, such as figure/ground and point of view.

In reality, sentence semantic and discourse structural considerations are complementary and compatible, not alternative or mutually exclusive. As the unit of description grows while resolution remains constant, the grain of the description becomes coarser. This is equally true of language users and theories. Discourse analysis and literature studies build on higher order abstractions which have reflexes on the sentential level. The stagnant, impressionist feel of Chekhov’s ‘imperfective telling’ turns out to be in part due to open, irresuttative (generic or progressive) event types in main clauses and closed events in subordinate clauses (Jensen 1990:395): Kogda vyshli v nastave, na nebe chut' brezzhilo ‘When they came to the city gate the sky was faintly paling.’ Literally, the focus is on how things are, not what happens. Proust’s “pseudoiterative” use of French imperfect frames events as instances of recurrent, habitual sequences associated to places and periods in the narrators life (Genette 1980:121). Bakhtin noted the frequency of suddenly in Dostoevsky’s and its virtual absence from Tolstoy’s “chronotopes”. Steinbeck’s Pearl uses sequences of stalls reminiscent of film cuts.

Abstractions relevant for temporal discourse structure include point of view, grounding, narrative progression and speed (pace). An example of perspective is the phenomenon that imperfectives appear as background regions around a reference time while perfectives appear as points figuring on it. Narrative progression specifically refers to the phenomenon that imperfectives do not advance a story while perfectives move it ahead. The speed or pace of the narration (narrated time or events per length of narrative, Genette 1980:87-88) is a matter of resolution.

My claim is that narrative is a topic structure. Topic structure concerns what narratives are about, what questions they answer (Carlson 1983). True to the title of a Moomin book, stories are about what happened then. More specifically, what happened to somebody and what they thought and did about it: A real story is not just any course of events, but a play of a game, with a number of interacting agents with beliefs, abilities, and preferences, pursuing their goals.

My more general thrust in this chapter is that it is not necessary to lose precision to make sense of literature. A dual alternative to top down approach is the bottom up method of stepwise abstraction: work out the logic of bits of narrative and generalise from that.

**Point of view**

Aspect (aspectus, vid) literally means perspective. Many writers in tense and aspect say that aspect variants do not describe different events, they just look at the same events from different points of view. The choice of aspect in a discourse depends on the perspective, i.e. on the relationship of the time of reference to the event. The choice of open/closed aspect chooses between looking at an event from the inside or from the outside, in other words, the time of reference is either embedded in it (bounds excluded) or embeds the event (bounds included). One chooses to describe either what happened in a period or what was going on at a point.

Examples of shifts of viewpoint from tense and aspect:

A happened before B / B happened after A. \( a < b = b > a \)

A was happening when B happened / B happened when A was happening. \( a \cap b < = b \cap a \)

A had happened when B happened / A happened when B was going to happen. \( a \cap \backslash \cap b = a \cap \backslash \cap \slash \cap b \)

To prove that aspect only changes point of view one is to prove that two descriptions of events are equivalent modulo point of view. Logical equivalence of descriptions modulo point of view is logical equivalence subject a set of equations relating the points of view. (Rather like unification.) For instance B is early is equivalent with B is late if B is between A and C.

Equivalence of descriptions modulo point of view is a conditional equivalence proof. It does not prove that the descriptions are equivalent absolutely, only that they are equivalent subject to a set of equations. Conditional entailment
is stronger than consistency simpliciter but weaker than equivalence simpliciter. As a source of nonmonotone contextual inference, it is a natural object of study in natural language semantics in general (van Benthem 1985:22).

Saying that temporal reference is subjective or perspectival amounts basically to this. Different choices of origin (point of view or perspective) can yield different but conditionally equivalent (consistent) theories true of the same model. Different choices of scale and granularity can yield different stories which have a consistent common extension to a fuller story of the same course of events. But none of this is specific to tense and aspect.

A point of view is an index or point of reference in the sense of modal logic or intensional pragmatics, i.e. an implicit global variable defining a local view on a structure. Each coordinate contributing to narrative structure thus defines a of point of view. I use the dialogue game framework of Carlson (1983) to guide the selection of indices relevant for analysing temporal discourse:

\[\text{time: temporal order and resolution of an event relative to other events}\]
\[\text{place: location of an event relative to other events}\]
\[\text{players: subjects of propositional attitudes (perception, knowledge, preference)}\]
\[\text{topic structure: position of an event in the logical structure of the narrative.}\]

In literary theory, the structuralist theory of narratology (Todorov 1966. Genette 1980 [1972]), Barthes 1975 develops structural distinctions under rubrics matching the title of this monograph: tense, aspect, mood, voice. Although the narratological notions are only metaphors of the linguistic ones, there are striking affinities between this line of work and the present developments, as will become apparent.

**Narrative tense**

Under tense, Genette (1980) understands not (just) the use of tenses (and aspects) in narrative, but (primarily) the overall temporal organisation of a narrative: the relative order of the events as they are told and as they happened, and the relative duration (length) of discourse accorded to them in the narrative.

**Narrative progression**

Narrative progression involves two (prima facie) rules. The first one is an iconic chronology principle (Panitz 1998:11): the order of telling agrees with the order of happening (a later event type does not denote an earlier event token). The second rule is the old Latin rule for aspect in narratives: perfecto procedit, imperfecto insistit oratio. Perfectives move a story forward, imperfectives do not.

The iconic rule is only one way to follow Grice’s (1975:45) maxim be orderly (Wilson/Sperber 1998). It is well established that there is no necessity to tell events in the order of happening (Nerbonne 1984, Comrie 1985:26ff, Couper-Kuhn 1987:10, Harkness 1987:60-61, Herweg 1991, Lascaride/Oberländer 1993). However, the iconic rule is a default: if the order does matter, and there is no other way to tell what the order is, then the order of telling is assumed to be the order happening. The following thus puts the blame on the other guy:

The guy punched me and I punched him.

But most times there are other clues to tell what the order is. Causal or logical considerations can decide the question:

Jack died. Max killed him.

Changes of scene or position imply changes of time, by the rule that nothing can be in two places at the same time. In the following example, the only event not timed by changes of location (but only by its position in the order of telling) is driving slowly. Its relevance becomes clear in the next sentence: he did not want to miss the dirt road.

Then he took Interstate 25 south and turned the wagon westward at the Rio Bravo exit. He drove slowly, counting the tenths of miles on the odometer. Near the river, he turned off the pavement onto a narrow dirt road. He got out of the wagon there, taped down the switch to keep the courtesy light off when the door was opened, and replaced the Herz license with the stolen plates. (Hillerman: The Ghost Way).

The aspect rule too is a cross-linguistic universal. For a classical description of the aspect contrast in Greek see e.g. Kühner (1896:§386). Lindstedt (1985:82ff) describes narrative progression with the Bulgarian aorist. By Eberle and Kasper’s (1994:150) principles the French passé simple drives the narrative action forward, the Imp is incapable of this. Aspect allows a listener to reconstruct a sequence of reference times from the narrative, as it were to calculate its inverse: the successive vantage points taken by the narrator reporting events as they appear to him. Examples of the rule in Portuguese translation:

He asked for water, and in the cup he put three drops of ammonia, and he pried open the baby’s mouth and poured it down. The baby spluttered and screeched under the treatment, and Juana watched him with haunted eyes. (Steinbeck: The Pearl).
‘Pediu (pf) um copo de água, onde deitou (pf) três gotas de amoniaco, abriu (pf) à força a boca da criança e fê-la (pf) beber. Coyotito cuspiu (ipf) e gemia (ipf) com o tratamento. Joana fitava-o (ipf) angustiada.’

**Under the treatment** reveals that the reactions of the baby and the mother take place while the doctor is doing his tricks. English relies on unmarked lexical aspect, the Portuguese uses grammatical aspects.

In the following case, the *clamored* is part of the same hubbub with *cried*, not a separate subsequent event. In the Portuguese translation, the first one has perfective, the second one imperfective. It would not be right to say that *clamored* is background to the main story line any more than *cried*, but it goes into detail what was said in it (as if the English had a progressive *were clamoring*). The imperfective in the last sentence of the translation matches the result state of the English pluperfect.

And then the chorus of the neighbours broke in. “He has found the pearl of the world”, they *cried*, and they joined their forefinger with thumb to show how great the pearl was. “Kino will be a rich man”, they *clamored*. “It is a pearl such as one has never seen.”. The doctor looked surprised. “I had not heard of it.” (Steinbeck, *Pearl*)

O coro dos vizinhos rompeu (pf): Ele encontrou a Pérola do Mundo - clamaram (pf) eles, fazendo uma argola com o polegar e o indicador para mostrarem como a pérola era grande.”Kino vai ser rico - afirmavam (ipf). - E uma pérola como nunca se viu. ‘O médico olhou (pf) surpreendido: - Não sabia (ipf) de nada.’

Jespersen (1949:§12.7.5) complains that sometimes it is not easy to see the reasons that made a writer alternate between simple and progressive aspect. But there are reasons. I would venture to go as far as to say that the choice between simple and progressive form is never without effect. Although truth is unaffected, different forms denote different events, even more subtly, allow different sets of alternative reconstructions even if they agree on the intended one.

The fog was rapidly dispersing; already the moon *shone* quite clear on the high ground on either side. It seemed to him that very far off a great throng *was forming*. It was menacing, *shouting*. It *stirred*, it *moved*, it was *advancing* …  (H.G:Wells, *War of the Worlds*).

Out of context, *shone* and *was shining* are equivalent, given *shine* is a dynamic state. However, in this context, *shone* is goal causative, meaning *cast light (on the ground)*, while *was shining* would better fit a locative intransitive context *was visible (on the sky)*. The second example is straightforward. There are three stages: the throng is stationary, it starts to move, and it is in motion, as indicated by the progressive-simple-progressive sequence.

**Theories of narrative progression**

There is a strand of research in the semantics of tense which tries to formulate narrative progression as a semantic rule. One of the early exponents is Dowty (1982:38), whose *temporal discourse interpretation principle* (pruned of irrelevant formal detail) says

A sequence of sentences is true when construed as a connected narrative discourse iff each sentence is true at a time equal to or relatively soon after the time of the preceding sentence.

Partee (1984) makes the rule sensitive to aspect, so an event predicate is placed within the current reference time and shifts reference time forward to just after the event. A state includes the current reference time and no shift takes place. Cf. also Dowty (1986).

Discourse Representation Theory (Kamp and Rohrer 1983) is one of the few truth conditional approaches to formalising temporal discourse. According to it, a discourse is true iff it is possible to homomorphically embed its discourse representation into the real world, i.e. to associate with discourse events real events that meet all the conditions, including those pertaining to temporal order, which the discourse representation specifies for the corresponding discourse events (Kamp and Rohrer 1983:252).

Kamp and Rohrer (1983:260) initially propose a stronger condition of narrative progression than Dowty, but exceptions similar to those already noted above lead them to weaken their narrative progression rule to a restatement of Dowty’s rule. Even the weakened principle still fails in one of their own examples (9), which is a list with no temporal implications between the members of the list.

With the italicised proviso, Dowty’s principle reads as a definition of connected narrative discourse, rather than an empirical claim. The same problem of circularity also besets Nerbonne’s (1986:86) principle of *Reichenbach’s pragmatics*, which is another restatement of Dowty’s narrative progression rule. Nerbonne finds it a recommendation of his approach that there is no level of “text” or “tense structure”, i.e. that it requires no appeal to the idea of listeners (or readers) “making sense of a description”. In my view, this is just what is wrong with it, and why it is riddled with counterexamples. Nerbonne notes himself that “it isn’t difficult to find counterexamples even in very careful narration. Occasionally events are obviously recounted out of order:”
Exceptions like Nerbonne’s (17) below are simply ruled outside temporally connected discourse: In my view, (17) below is temporally as connected as one could wish: before is anchored to Tom arrived while Sue arrived is a definite reference licensed by the day before.

Tom arrived. Sue arrived the day before.

Tom\then1\now \& Sue\then2\day\then1\now

Nerbonne’s example (26) shows that an open event can be properly separated from the consequent state of the immediately preceding change: Trimmed down to its essentials, the example goes

The friends agreed to meet again in New York on Thursday. Al went to New York on Tuesday. … The others were all there too.

game<meet\Thursday \& Al\(Tuesday’<Thursday\) \& others\Thursday

The point of the example is that the last sentence can refer back to the first sentence of the story, disregarding temporal references in between. This is a good example of how and why a simplistic rule of narrative progression is bound to fail: topic structure is in general not linear (Carlson 1983).

A converse exception is

Bo said that he talked with Tim. Tim hadn’t heard the news. ¬hear\talk\then2\say\then\now

The problem for Nerbonne here is that the pluperfect in the second sentence suggests that Tim hadn’t heard the news prior to his talk with B and not merely prior to Bo’s report of the talk. In my view, nothing stops hadn’t from referring to talked instead of said, for instance if Bo and Tim are both present and being cross-questioned. The former reading implicitly adds Bo said that, the second Tim said that. Both are possible, but reconstruct different stories. Identification of temporal antecedents is not a matter of grammar, but topic structure, i.e. coherence. Another example (abbreviated):

Karlinahami broke in. … Babun eagerly seized upon this suggestion. Silindu took no part in the discussion.

After Karlinahami intervened, he became silent.

The “problem” is that Silindu’s actions are told in retrospect. Here a plausible discourse structure is who said what when, which justifies going over the conversation again for Silindu’s part in it.

Nerbonne (1986:94) ends up suggesting that narrative progression is just a scheme of conversational implicature - i.e. a principle which is applied in the absence of contrary indication. In my view this is just what it is. Narrative progression reflects a default discourse structure for narratives, easily supplanted by others whenever they make better sense of a story.143

A common type of counterexample (Kamp and Rohrer 1983) is an extended flashback starting out with a pluperfect but going over to simple past and finally returning to top level with another simple past referring to where the flashback began. Eberle and Kasper (1994:153), working in DRT, relativise narrative progression to rhetorical relations. The simple progression rule applies to continuation structures and fails for other rhetorical relations, including elaboration and list. The DRT account of discourse interpretation in Eberle and Kasper (1994) is strongly procedural and geared to handle nested flashbacks (there is a stack of earlier reference times). The only example of applying the machinery is the interpretation of the following small discourse, where it seems rather superfluous.

2. Le 3 octobre il était parti. Afric.-Afrique\Oct3<Oct6\now
4. Et maintenant il était là. Paris\Oct6\now1\now

In my views, beyond the inherent meanings of the individual sentences, the only thing the interpreter has to note is that the whole story sticks to the same reference time le 6 octobre. It follows that le lendemain in 3 must refer to le 3 octobre in 2. The past tense of 4 tells that maintenant cannot refer to speech time, i.e. we have a case of style indirect libre.

Seligman and ter Meulen (1993) present an algorithm for interpreting narrative text based on diagrams called dynamic aspect trees. They provide the trees with a formal semantics which supports deduction from the temporal relations of sentences in a connected narrative. The rules for constructing aspect trees constitute a variant of the narrative progression rule. A new feature is that rules for opening and closing nested narrative sequences consider not only event type but the coherence (logical consistency) of the story.

143 Its role is similar to the more specific scripts and schemas of Schank/Abelson 1977. They provide patterns of inference and questioning which can guide the logical reconstruction of a discourse.
Alternative view

Another line of thought (Black/Bower 1979, Haberlandt et al. 1980, van Dijk 1982, Dahl 1984, Comrie 1986, Moens/Steedman 1986, Cowper-Kuhlen 1987, Schopf 1989, Caenepeel/Moens 1994, Carlson 1994, Bartsch 1995, Molendijk 1993, 1996, Wilson and Sperber 1998) treats narrative progression as a discourse phenomenon. Cowper-Kuhlen (1989), for one, shows that none of the grammatical criteria usually proffered for backgrounding vs. foregrounding or description vs. narrative progression are necessary or sufficient alone: past or some other tense, progressive or bounded aspect, main or subordinate clause. The central role is played by current reference time (Partee 1984), the time at which each event is understood to happen. Current reference time is depends on tense, aspect, and temporal adverbials, but not only on them, but on any and all contextual and pragmatic clues a discourse and its context may give. Understanding temporal relations in a discourse is in no way different, simpler or more complicated, from making sense of a discourse in general.

Essentially the same conclusions about narrative progression are drawn in Schopf (1989) after a painstaking study of temporal reference in a passage from James Joyce:

A principle of automatic progression which attributes the forward movement of reference time in a narrative texts exclusively to ... ‘aspectual character’ ... cannot be the whole answer since it cannot provide a fully satisfactory model of the processing of narrative discourse as it occurs in the reader. ... We propose instead a model in which the positioning of the reference time of a new sentence in a narrative is the result of a computation which evaluates all the information conveyed by this sentence against the information supplied by the preceding text, and which, in addition to this, relies on our general cognitive faculties and all the information we have accumulated about extra-linguistic reality. (1989:277).

How little temporal coherence depends on tenses is proved by the possibility of transposing stories into different tenses or even to nonfinite form. It shows that narrative progression is not coded in the semantics of tenses. Any verb forms can exhibit it, including infinitives. Cowper-Kuhlen (1987:24) mentions Chafe’s pear stories (Chafe 1980) for present tense and Bronzwaer (1970:70ff) for future tense narratives. Narrative structure is imposed by our understanding of the events, not by the tenses coding them (Seligman and ter Meulen 1992).

Cowper-Kuhlen’s (1987) list of exceptions to default assumptions of narrative progression is worth a closer look.

1. A state in a subordinate clause can move a story forward:

   I promised to drop in and returned to the dining room and to my meal. When I had finished eating I went up to my room, fifth floor front.

   This shows that the pluperfect had finished eating can act as an acquisition to mark the end of the meal.

2. A progressive can move a story forward:

   She looked at him, smiling. Then she was in his arms and he was kissing her with a fine certainty that surprised him.

   Significantly, there is the little word then (‘the next moment he knew’) to fix a new reference time. Leaving it out loses the sequence. A more convincing case is Hinrichs’ (1981:66)

   James switched off the light. It was pitch dark around him, because the Venetian blinds were closed.

Here it is rather obvious that it got dark only after James switched off the light. Changing off to on would invert the discourse from an event-consequence relationship into an action-explanation relationship:

   James switched on the light. (Why?) It was pitch dark around him, because the Venetian blinds were closed.

A free indirect discourse pluperfect it had been pitch dark around him would sound better in a novel, because it would preserve James’ perspective. Molendijk (1994) provides similar examples involving French imparfait and explains them by a similar appeal to implicit discourse structure.

3. Closed event types need not move a narrative forward:

   I finished my cigarette and lit another. The minutes dragged by. Horns tooted and grunted on the boulevard. A big red interurban car grumbled past. A traffic light gonged.

Cowper-Kuhlen’s observation is right, but the example is not the best instance of it. Clearly this particular text indicates that time dragged by, why it says so in so many words. Things probably even happened in the order described. The valid point here is that it really does not matter whether they did or not, because nothing further depends on them and they do not depend on one another, they just fill up time. It is a common literary trick to slow down things by describing idle, causally unrelated sequences of events, trivial things one would have time to pay attention to when nothing of note is going on. Better examples are

Kasparov gave up. The computer had won.
The question startled her. She pinched her lower lip between her teeth and answered reluctantly.

*pt* A María contou uma história e o Pedro ouviou-a. ‘Mary told (pf) a story and Pedro listened (pf) to her.’

Johanson (1998)

In the Kasparov example, the asyndeton can be paraphrased either by for (victory causes surrender) or by then (surrender causes victory). Similarly for the second example. With for, biting her lip is what shows she is startled, with then, she bites her lip to regain composure.

The *then* reading is a counterexample (in English) to Eberle and Kasper’s (1994:157) claim (about French) that a pluperfect following a perfective past inverts the order of the events.

Jean poussa un cri. Son père l’avait giflé.

This too depends on rhetorical structure. Compare also Dowty’s (1986:47)

John hurried to Mary’s house. But Mary had left in the meantime.

The reference time of the second sentence is likely to be the endpoint of John’s journey, when John finds Mary gone; the hurrying and leaving happen simultaneously.

Subordinate clause events can be foregrounded.

I promised to drop in and returned to the dining room and to my meal. I had just finished eating when I heard myself being paged.

I didn’t move. She gave me another cute glance and went on towards the front door. She had her hand on the knob when we both heard a car coming. (Chandler, *The Big Sleep*).

This sort of inversion where *when* means but *then* is well known. (called narrative *when*, Hamann 1989:72, Declerck 1997:§10) In a narrative *when* sentence, the main clause event frames the *when* clause event; the *when* clause event is new, unexpected. The main clause is open and the *when* clause closed. Compare

I went in. I was inside when I turned on the lights.

I went in. I was barely inside when someone turned on the lights.

Only the last one is an inversion. The contrast highlights the properties of inverted *when* clauses: the *when* clause is a new closed event timed by the main clause, the main clause is open and (because it times the *when* clause) of the same granularity as the *when* clause. The main clause harbors adverbials like *barely* and the *when* clause *suddenly*.

Open event types can move events forward in narratives.

She nodded at last, *turned slowly* and walked back to her little desk in the corner. From behind the lamp she stared at me. I crossed my legs and yawned. Her silver nails went out to the cradle phone on the desk, *didn’t touch it*, dropped and began to tap on the desk.

*Turn slowly* is a comparative change which is bounded from both ends by the nod and the walk (one is not likely to do these things at the same time). *She stared at me* is a state, but it is implied to begin when she got seated at the desk (how else could she stare from behind the lamp?). My crossing my legs and yawning does not prevent her from staring, so she probably went on staring at me through the yawn. Perhaps she even reached for the phone without turning her eyes off me. Didn’t touch it is the negation of an acquisition and thus inherently vague about aspect. Obviously she wasn’t touching the phone all along, but it only becomes news after she reaches for it. An aspect language would probably use perfective aspect here to indicate the temporary relevance. Summing up, when grammar does not indicate it, we let context and world knowledge decide the choice of aspect. Compare Dowty’s (1986:53) example from Dry:

John asked where the children were. Mary looked anxiously out the window. Their coats lay on the lawn, but they were not in sight.

Here, the activity *look out the window* is understood as an event because one infers a causal relation between the question and the look. This is an inference to the best explanation, very like those by which we take *they to* refer to the children instead of John and Mary or the coats.

**Narrative as a topic structure**

Why, when, how do aspects make the discourse (reference time) proceed? If it is due to dialogue structure, as I am suggesting, it must be through the questions (inferences) they generate (von Stutterman/Klein 1989). The underlying dialogue structure can be reconstructed using dialogue game methods (Carlson 1983) turning implicit points of view, premises and inferences into interpolated explicit moves.

The topic of a narrative is summarised by *What happened? How did it happen?* Inside the narrative, the story proceeds with *What happened then? What happened next?* and it stops for description and comment with *What was it like (to someone) then?* Such topical questions are no different in kind from those that generate alternative discourse structures,
such as lists, exemplifications or explanations. In particular, I see no reason to construe the latter topic structures as exceptions to the former (Dowty 1986:57).

For a Finnish or Swedish speaker, English then is ambiguous between a temporal location adverb silloin/då ‘at that time/point’ and a relational temporal or discourse adverb sitten/sedan ‘after/in addition to that, next’ (Quirk 1974 s.v. then). At that point denotes (the final state of) the same event, next the next event.

\[\text{fi Poika loi minua. Silloin/sitten minä loi häntä.}
\]

The boy punched me. Then (at that point/next) I punched him.’ punch.punch

The difference in meaning is clear: at that point makes the second punch a counterpunch to the first one, next just orders the events. The paraphrases go with different topic structures and stress patterns: What happened at that point? with emphasis on then and punch, versus What happened next? with emphasis on I and him. Only at that point makes sense for Then I lost a tooth/my patience, where the event is a consequence rather than the next considered move. The distinction is particularly clear when the second event is open:

She told me she was leaving. (At that point/*next) I was devastated.

In general, open event types paint the background: description, explanation, and evaluation (Jespersen 1949:§12.6.4) Why? Simply because descriptions, evaluations and many explanations are open event types. they answer questions Where/when was it? What was it like (then/there)? What should/does/did someone think about it? What was the result? How are things now? and generic explanations Things always happen that way, He is always like that etc. are aspectually states.

When do these topic questions arise? When events change state (Kamp and Rohrer 1983:259). From the assertion of a change one can deduce the existence of a new state. One can then ask what the result state was like or what further events, whose antecedent state is the consequent state of the first one, were caused or enabled by it. This is why then in these topical questions refers to the consequent state. Partee (1984:fn35) quotes Remko Scha's suggestion that the introduced reference time includes the end of the given event (the beginning of the associated ‘resultant state’ if there is one). This suggestion generalises to locative anaphora, where the reference location of a motion sentence is the end location (goal) of the moving subject (theme): I went home from work and stayed there.

Partee (1984:262) has a nice example of a discourse which is anomalous because the topic What was it like then? does not fit the consequent state:

People began to leave. The room was empty. The janitors came in.

Beginning to leave does not yet result in the state of the room being empty, so a gap is felt between the first two sentences in the discourse. It could be filled by changing began to leave to (had) left or by adding soon or when to the second sentence.

As expected by this account, in an asyndetic sequence of two events, it is the first one that, when perfective, makes the narrative proceed, shifting reference time forward for the second event. In the latter case, the new then describes a situation brought about by the change (Kamp and Rohrer 1983:259). The second one can be closed or open. An open event is sequenced after a closed one when the first event produces a cause (necessary condition) for the second. Being open, it does not move narrative forward, but describes the resulting scene (Leinonen 1982:100).

He told me I had failed. I was really unhappy (when I heard it).

\[\text{pt ‘O hross caiu (pf) aparatosamente na águia, a dez jardas do monstro, mas o hnakra estava (ipf) morto.’}
\]

Almost at once the hross was dislodged and fell with a wide splash nearly ten yards away. But the hnakra was killed. (C.S. Lewis)

\[\text{fr Elle s’arrêta un instant. Elle consultu un petit carnet de notes, leva la tête, regarda et continua son trajet.}
\]

Arrivée à la dernière rangée, elle s’engagea sur l’herbe mouillee. Elle se penchait sur chaque croix et lisait les noms.

‘She stopped (pf) for a moment. She consulted (pf) a small notebook, raised (pf) her head, looked (pf) around, and went on (pf). When she arrived to the last row, she got down (pf) on the wet grass. She bent (ipf) toward each of the crosses and read (ipf) the names.’

\[\text{ru Zhenshchina naklonilas’ k nemu, vsišla na ruki i celovala ego. ‘The woman bent (pf) towards him, took (pf) him in her arms and was kissing (ipf) him.}
\]

\[\text{ru Fedja prosnulsija, molcha lezhal rjadom so mnoju… ‘Fedja woke/had woken up (pf) and lay/ was lying (ipf) quiet beside me.’}
\]

How are narratives (re)constructed? There are some obvious strategies. Non-contiguous and noncontingent events are related by temporal adverbials precisely where the default narrative script what happened then? falters. Subjective events (perceptions, decisions) are interspersed with objective ones and used to clock the latter.
Imperfectives are sequenced by explicit connectives (Kamp and Rohrer 1983:258). In many prima facie cases of sequenced imperfectives the events are in fact closed by adverbials or timed by intervening perfectives. According to Leinonen (1982) the imperfective forms in the first example below “mention each action separately”, i.e. do not form a narrative but a list of activities with topic question What chores did she do in what order?

V subbotu ona snachala stirala/postirala bel’e, potom pisala/napisala pis’mo… ‘On Saturday she first washed (ipf/pf) the laundry, then wrote (ipf/pf) a letter…’.

S kakimi-to neznakomymi liud’mi on snachala nosil’ ubityh, zatem taskal’ shlapy i rel’sy, razbiral’ zavaly iz razbitih i obgorelyh vagonov. ‘At first, he carried (ipf) the dead away with people he didn’t know, after that he carried (ipf) sleepers and rails and sorted out (ipf) heaps of broken and burned-out carriages.’

On dolgo hodil’ (ipf) po ulicam, zatem sidel’ (ipf) v gorodskom sadu… ‘He walked for a long time in the streets, then sat in the municipal park…

Ja proshelsja neskol’ko raz po komnate, ostanovilsja pered zerkalom, dolgo, dolgo smotreli na svoe skonfuzhennoe lico i, medlenno vysunul’ golovu. ‘I walked (pf) up and down the room a couple of times, stopped (pf) in front of the mirror, looked (ipf) at my perplexed face for a long, long time, and, (having) slowly put out (pf) my tongue, shook (pf) my head with a bitter smile.

Frequently, a series of implicit acts of perception can be interpolated, making the story a running commentary:

Lady Dalrymple’s carriage, for which Miss Elliot was growing impatient, now drew up; the servant came to announce it. It was beginning to rain again, and altogether there was a delay, a bustle, a talking, which must make all the little crowd in the shop understand that Lady Dalrymple was calling to convey Miss Elliot. At last Miss Elliot and her friend. … were walking off; and Captain Wentworth, watching them, turned again to Anne, and by manner, rather than words, was offering his services to her.

A moment later brother A was opening the iron gate … The dog was following him to the street. The cab was moving off, when there was a growl and a lurch - the dog had broken away and was running after it. Feeling anxious about the dog he drew up the cab for a moment. The faithful creature was running under the driver’s seat.

In reconstructing temporal discourse, it is important to keep in mind all the time which events one is talking about. In It was dark. I had turned off the light. the event types dark and on/off are indeed “mentioned” in reverse order. But the event type of the whole discourse is dark\non/off\off which denotes just one time, the time of the darkness following the turning off the light.

Another crucial distinction is one between what is said (asserted or entailed), and what is just implicated in a discourse, perhaps only relative to a rich set of implicit background premises. According to the dialogue game definition of discourse (Carlson 1983:xiv), both writer and reader face the task of reconstructing the narrative into a coherent story, subject to their understanding of the topic structure and other implicit premises of the work. Each reading brings in its own set of premises and inferences which may or may not match those the writer had in mind.


Mary turned the corner. When John saw her, she crossed the street.

One likely story is that Mary turned the corner, becoming visible to John. Mary's noticing that caused her to cross the street (perhaps to avoid him). The first sentence provides a result state (Mary having turned the corner) which meets with John’s seeing her and constitutes the initial state of Mary's crossing the street (so there was a moment when Mary was around the corner, the two saw one another, and Mary decided to cross the street). The next thing that happens is that Mary crosses the street. Note how the story under this reconstruction implicitly takes Mary’s point of view: John saw her must be construed as an event perceived by Mary in order to make the causal connection.

The reconstruction is by no means the only possible one. Contrastive stress on John and street would suggest an entirely different discourse structure, with the topic What did Mary do when?

My point here is that the flow of time through a course of events is reconstructed, inferred or guessed from the utterances, using tenses and aspects as clues. There may be many reconstructions compatible with a given narrative (Carlson 1983). Inferences go both ways here: our understanding of the events guides the choice of forms, conversely, the choice of forms imputes a point of view on a course of events by coercing or suggesting a given set of choices of reference times/events.

According to this view, reference times are nothing but times (events, occasions) referred to explicitly or implicitly. They need not be directly denoted by any part of the sentence (Bäuerle 1979, Partee 1984:265). It is a question of inference to decide what occasion then refers to in narratives, just as much as it is one to decide what it refers to in I hit the table with the hammer and it broke. Wilson and Sperber (1998) provide further arguments of the same kind.
A simple constructed example of the interaction of topic structure and timing is the following (Lascarides/Asher 1991, Lascarides/Oberlander 1993:29, Panitz 1998:70). The intended timing follows from the topic structure below:

Guy had a lovely evening last night. He had a great meal. He ate salmon. He devoured lots of cheese. He won a dancing competition.

\(((lovely\text{\&}night)<now)\cap((<meal\text{\&}<salmon\text{\&}cheese<)<dance<)\)

Guy had a lovely evening last night.
What did he do (last night)?
He had a great meal.
What did he eat (at the meal)?
He ate salmon. He devoured lots of cheese.
He won a dancing competition.

Each event type details the foregoing one as the story moves down the topic structure. The topic structure follows a well-worn script for having a "lovely" evening (first hogging, then sex related social success; fish for firsts, cheese for seconds). Tenses do no work here. Timing follows from topic structure, topic structure from script knowledge.

Another simple what happened then style story is Kamp and Rohrer (1983)

L’annee derniè re, Jean escalada le Cervin. Le premier jour, il monta jusqu’a la cabane H. Il y passa la nuit. Ensuite, il attaqua la face nord.. Douze heures plus tard, il arriva au sommet.

Last year, Jean climbed Mt.Cervin. On the first day, he climbed to the H cabin. He spent the night there. Then he attacked the north face. Twelve hours later, he reached the top.

Cervin\text{\&}year<now>\cap then1<now>\land day<now>\cap then1<now>\land cabin\text{\&}then2<now>\land then2<now>\land cabin\text{\&}then3<now>\land then3<now>\land face\text{\&}then4<now>\land then4<12h<top<top<then5<now

Other topic structures

As predicted by this account, apparent exceptions to narrative progression indicate the presence of other dialogue structures: explanation, exemplification, lists, etc. When the What happened then? question does not arise, so some other topic must be found. Open events do not produce changes of state. Without temporal connectives, their likely topic is What was it like then? – a description of a scene of simultaneous, overlapping, or freely ordered events (Leinonen 1982:99):

V okruzhnom voennom komissariate bylo mnogoljudno i zhumno. Rezko drebezhdali telefonyje zvonki, hlopal dveri, vyhodili i vhodili vooruzhennye ljudi, iz komnat donosilas’ suhaja drob’ pishushchih mashinok.

‘The district military commissariat was (ipf) busy and noisy. Telephones rang (ipf) shrilly, doors banged (ipf), armed men were coming (ipf) and going (ipf), and the dry rattle of typewriters was coming (ipf) from the offices.’

Petr Mihajlovich el zemlaniku, a Vlasich i Zina smotreli na nego molcha. ‘Petr Mihajlovich was eating (ipf) strawberries, and Vlasich and Zina watched (ipf) him silently.’

Cigane peli, svisteli, pljasali… ‘The gypsies sang (ipf), whistled (ipf), danced (ipf) . . .’

A sequence of closed events is also free if there is no causal dependence (one event does not presuppose the consequent state of the other), but the relation of the events is a logical one, e.g. a list of instances of the same type (Leinonen 1982:97ff).

Then Monmouth threw himself to the ground, and crawled to the King’s feet. He wept. He tried to embrace his uncle’s knees with his pinioned arms. He begged for life, only life, life at any price.

Tarantas po-vcerashnemu zaprygal, zaviezhal, zastuchalo neistovo vedro… ‘Tarantas, the same as yesterday, started to jump (pf) and whine (pf), the bucket started banging (pf) wildly…”

Inclusion of events in general entails simultaneity, not succession (Schmerling 1975):

On postarel za etu nedelju, osunulsja i potemnel v lice. ‘During this week he aged (pf); his face grew lean (pf) and dark (pf).’

I spoke to John and discovered that he was charming.

As has been frequently pointed out, explanatory topic structure allows reverse-causal interpretations (Wilson and Sperber 1998:17):
The glass broke. (Why?) John dropped it.

It is well known that *and* is more restrictive about implicit topic structure than asyndetic discourse. Compare

I could not pay my bill. (And) I lost my wallet.
I lost my wallet and I could not pay my bill.

Addition of *and* destroys the action-explanation reading of the first discourse, making it more like an unordered list of grievances *What went wrong today*. The second discourse is a good narrative. Why? Rule *(D.and)* of Carlson (1983) explains why.

*(D.and)* When a player has put forward a dialogue move, he may continue on the same topic by conjoining a further sentence to it by *and*.

The topic of a narrative is *What happened then?* This topic is addressed by both conjuncts of *I lost my wallet and I could not pay my bill* $\neg \text{wallet} \land \neg \text{pay}$, which story is supported by the likely causal connection $\neg \text{wallet} \leq \neg \text{pay}$. The opposite arrangement $\neg \text{pay} \land \neg \text{wallet}$ spells an unlikely story $\neg \text{pay} \leq \neg \text{wallet}$. In sum, the view of narrative progression as just one topic structure among many allows considering deviations from it not as exceptions, but as variations to what really is an exceptionally simple discourse strategy.

Molendijk (1996) lists five common topic structures for French imparfait. Not much needs to be said and done here to get the temporal relations right.

causality/explication Jean alla chez le médecin. Il était malade.
manner/detail Un homme se promenait dans la rue. Il boitait fortement.
background Pierre rentra. Il pleuvait.
consequence/result Il alluma les lampes. La lumière éblouissante donnait à la pièce un air de tristesse.
incidence Pierre se promenait dans la rue. Il trébucha sur une pierre.

Table 43

<table>
<thead>
<tr>
<th>Table 43</th>
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</table>

Ikola (1949:60) distinguishes two main strategies in conducting narrative: 1) the reference time shifts with the events, with the result that simple tenses suffice to relate them, or 2) the reference time sticks to the main plot, and subsidiary events are related to that, in which case complex tenses get to be used. Languages and narrative styles may prefer one or the other.

**Narratology**

Genette (1980) surveys a number of established literary "exceptions" to narrative progression:

**Achrony** Order of events is not told in narrative

**Anachrony** Events are told in reverse order of happening

**Analepsis** Event happened earlier than told

**External analepsis** Event happened before story

**Internal analepsis** Event happened earlier in story

**Prolepsis** Event happens later than told

**External prolepsis** Event happens after story

**Internal prolepsis** Event happens later in story

**Repetition** Event is told more than once

**Advance notice** Event is mentioned before it is narrated

**Recall** Event is mentioned after it has been narrated
A passage of Remembrance of Things Past was analysed for its chronology by Genette (1980:43):

Swann now found equally intelligent anybody who was of his opinion, his old friend the Prince de Guermantes and my schoolfellow Bloch, (B) whom previously he had avoided (C) and whom he now invited to luncheon. (D) Swann interested Bloch greatly by telling him that the Prince de Guermantes was a Dreyfusard. "We must ask him to sign our appeal for Picquart; a name like his would have a tremendous effect." But Swann, blending with his ardent conviction as an Israelite the diplomatic moderation of a man of the world, (E) whose habits he had too thoroughly acquired (F) to be able to shed them at this late hour, refused to allow Bloch to send the Prince a circular to sign, even on his own initiative. "He cannot do such a thing, we must not expect the impossible," Swann repeated. "There you have a charming man who has travelled thousands of miles to come over to our side. He can be very useful to us. If he were to sign your list, he would simply be compromising himself with his own people, would be made to suffer on our account, might even repent of his confidences and not confide in us again."

Nor was this all, Swann refused his own signature. He felt that his name was too Hebraic not to create a bad effect. Besides, even if he approved of all the attempts to secure a fresh trial, he did not wish to be mixed up in any way in the antimilitarist campaign. He wore, (G) a thing he had never done previously, the decoration (H) he had won as a young militiaman, in '70, (I) and added a codicil to his will asking that, (J) contrary to his previous dispositions, (K) he might be buried with the military honours due to his rank as Chevalier of the Legion of Honour. A request which assembled round the church of Combray a whole squadron of (L) those troopers over whose fate Françoise used to weep in days gone by, when she envisaged (M) the prospect of a war. (N) In short, Swann refused to sign Bloch's circular, with the result that, if he passed in the eyes of many people as a fanatical Dreyfusard, my friend found him lukewarm, infected with Nationalism, and a militarist. (O) Swann left me without shaking hands so as not to be forced into a general leave-taking.

In my notation, an analysis of the explicit temporal devices could yield a more surface true formula:

\[ ((A>B) \cap C \cap D < (F \cap E) \cap (G \cap H) \leq (I \cap J) \leq (K \cap L) \leq N) \leq O \]

This leaves open the timing of the flashbacks previously, days gone by or anticipations (Swann's funeral). Given the collateral information available to Genette, the partial ordering above reduces to a total order of the various events involved:

\[ J < K < E < (A \cap O) < C \cap D < F < N < I < K < L < M \]

Comparison of the two formulas expresses Genette's finding in my notation: the concurrent events A and O bracket between them a whole series of events alternating between past and future and extending way past them to days gone by and into the future yet to come, a narrative strategy typical for Proust.

One of Genette's (1980:§3) contributions to literary theory is the establishment of generic narrative as a strategy in general and for Proust in particular. Genette (1980) in effect argues that Proust's A la recherche du temps perdu is a series of generic reminiscences about different places in the narrator's life, i.e. the overall topic structure is what was it like (for Marcel) where (at what time). A clear instance are the last forty pages of Combray, where Proust describes and contrasts two walking routes home, so that the order of narration depends essentially on the location of the sites (Genette 1980:84-85*). Genette (1980:137) lays out the detailed topic structure of the passage as a classification of returns home by frequency as follows:

<table>
<thead>
<tr>
<th>returns home:</th>
<th>always: early</th>
<th>ordinarily: fairly early</th>
<th>spring: twilight</th>
<th>often: cold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>summer: sunny</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rarely: later</td>
<td>mostly: dark</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sometimes: opalescent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 45

A consequence of this type of topic structure is that the cause-effect aspect of canonical narrative (what happened then?) is played down. As Genette (1980:140) says, before and after are only variants of the same theme of events varying, not evolving. This is no surprise from an aspeccual point of view: generic imperfectives define states, not changes. Genette (1980:142):

Likewise, the love between Swann and Odette, between Marcel and Gilberte, will develop to some extent by iterative plateaux, marked by a very characteristic use of those thenceforth's, since's, now's which treat every
story not as a train of events but as a succession of states ceaselessly substituted for each other, with no communication possible.

In more concrete terms, a favourite narrative shift in Proust is of form $\text{gen e} < \text{gen f}$, an event type which orders two generic states in a loose, interlaced sequence. Blindness to change seems to be inherent to Marcel's point of view (Genette 1980:143):

She spoke of a change the occurrence of which I could verify only in observing it from without, finding no trace of it within myself, for it was composed of two separate states on both of which I could not, without their easing to be distinct from one another, succeed in keeping my thoughts fixed at one and the same time. *(Remembrance of Things Past I:538,*).

Reminiscences "reduce diachronic periods to synchronic epochs and events to pictures - epochs and pictures that memory arranges in an order not theirs, but its own." (Genette 1980:156) In more concrete terms, the topic structure of memories: *how it used to be* is distinct from and not (necessarily or always) compatible with the narrative *what happened then*.

**Narrative duration**

Distinguish *narration*: a complex event token where someone tells someone something; *narrative* (*récit* Genette 1980 or *fabula* Dry 1983, Reinhart 1984): event type instantiated by a narration; and *story* (*histoire* Genette 1980, *sujet* Dry 1983, Reinhart 1984): a course of events partially described in a narrative. The story need not be the "whole" story either: it may still only be a partial account of everything that took place. A narrative can omit events that belong to a story, and tell some that properly belong in another story. In terms of our calculus, all of these objects (narration, narrative, story) are complex event types. Another term used by cognitive psychologists to describe stories is *episode* or *episodic structure* (Black/Bower 1979, van Dijk 1980, Haberlandt et al. 1980, Schubert/Hwang, 1989, Irandoust 1994).

**Structure of narrative**

Labov (1972:359ff) defines narrative as matching a verbal sequence of clauses to the sequence which actually occurred. Labovian iconic narrative is related to the notion of *script* (Shank and Abelson 1977). I use the term to refer to a ground event type which tells events in the order of happening. Interesting narratives diverge from the script in the order of telling: there are summaries, previews, flashbacks and digressions. But given a calculus of events, a normal form theorem for narratives is suggested:

*Every narrative can be rewritten as a join of scripts.*

This is analogous to disjunctive normal form theorems in tense logics (von Wright 1963:34) and to the definition of a well-formed dialogue game in Carlson (1983).

In general, the relation of a narrative to the story can be arbitrarily complicated, as it is based on coherence, which in turn reflects logical inference and rational decision (Carlson 1983). The temporal and aspectual complexity of a narrative could be measured by the number of steps needed to reduce it to Labovian normal form.

It has been noted that a narrative as a whole has the structure of an event description (Pollak 1960, Genette 1980:30, Fludernik 1993:212): there is a beginning: *an initial state* (abstract or orientation), a middle: *a change* (narrative or complicating action), and an end: *a final state* (conclusion or evaluation). This basic structure repeats itself within the narrative with varying granularity. Myhill (1992), elaborating Labov (1972), sections narratives into *abstract, orientation, complicating action, evaluation,* and *coda.* The abstract is an initial summary of the narrative. Orientation sets the scene. Complicating actions tell the actual sequence of events. Evaluations comment and explain the events. The coda is a final summary or a conclusion of the narrative. In formal grammar terms, Labovian narrative is a recursive event type satisfying the following inclusions, or context free rules:

- $\text{action} \rightarrow b$
- $\text{description} \rightarrow a$
- $\text{announcement} \mid \text{orientation} \mid \text{evaluation} \mid \text{conclusion} \rightarrow \text{description}$
- $\text{abstract} \mid \text{summary} \mid \text{action} \rightarrow \text{narrative}$
- $\text{coda} \rightarrow \text{summary} \mid \text{conclusion}$
- $\text{opening} \rightarrow \text{announcement} \mid \text{abstract}$
- $\text{narrative} \rightarrow \text{opening}?.(\text{orientation}?.\text{action} \cdot \text{evaluation}?)^+.\text{coda}$?

Here, *action* is the narrative name for closed event types and *description* for open ones. Every narrative contains at least one action. Abstract and summary denote the entire story on a coarser resolution. Orientation describes (at least) the initial state of the action, evaluation and conclusion (at least) its final state. (For symmetry, I have added announcement of a final state as an alternative opening of a narrative.)
In my view, narrative is primarily defined by its topic structure (Carlson 1983). As Labov points out, the question which a narrative answers first and foremost is What happened then? (Couper-Kuhlen 1989:11-12). Each type of section goes with a characteristic topics (questions) which set the tense and aspect type of the section.

| opening | How is everything? What is new/the matter? What has (not) happened? | present | open |
| orientation | When/where was it? What was it (like) (then/there)? | past | open |
| action | What happened? How did it happen? Why did it happen? What happened then/next? | past | closed |
| evaluation | So what? What does/did/should someone think about it? | past | open |
| coda | What is the result? What has happened since? How are things now? | present | open |

Table 46
There are typical topical questions that take a story from one section to another. Some keep the same resolution (What? When? Where?), some go up (Why? So what?), some down (What for? How?). A complete story can form a section in another story. Note that there are no specific questions for getting from a background section back to the action. Similarly, the conclusion can come at any point, because it summarises several things said so far. Such shifts in discourse structure can be marked by tense and aspect shifts (examples below).

| abstract | Like what? How did it happen? | down | action |
| action | How did it happen? | down | action |
| action | What happened next? | same | action |
| action | What was it like (then/there)? Where/when was it? | down | orientation |
| action | Why did it happen? | up | orientation |
| action | So what? What should/does/did someone think about it? | up | evaluation |
| action | What has been the result? How are things now? | up | conclusion |
| orientation | What happened then? | up | action |

Table 47
The following Labovian narratives exemplify variations of these topic structures:

abstract Were you ever in a situation where you were in danger of being killed? action My brother put a knife in my head. How’d that happen? Like kids, you get into a fight, and I twisted his arm up behind him. orientation When was this? This was just a few days after my father died…

abstract.action.orientation
**abstract** Three weeks ago I had a fight with this other dude outside. **orientation** Why did it happen? He got mad ‘cause I wouldn’t give him a cigarette. **evaluation** What do you think about it? Ain’t that a bitch?

**action.orientation.evaluation**

**action** I was given the rest of the day off. **conclusion** How are things now? And ever since then I haven’t seen the guy ’cause I quit. I quit, you know, No more problems.

**action.conclusion**

### Resolution

Genette (1980) divides canonical forms of narrative rhythm in literary tradition into four as follows:

<table>
<thead>
<tr>
<th>type</th>
<th>pace</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>pause</td>
<td>narrative time / story time = 0</td>
<td>description or commentary</td>
</tr>
<tr>
<td>scene</td>
<td>narrative time / story time = 1</td>
<td>dialogue</td>
</tr>
<tr>
<td>summary</td>
<td>narrative time / story time &lt; 1</td>
<td>prologue, epilogue, transition</td>
</tr>
<tr>
<td>omission</td>
<td>story time / narrative time = 0</td>
<td>gap in the narrative</td>
</tr>
</tbody>
</table>

**Table 48**

The fifth tempo of slow movement (narrative time / story time > 1) is dismissed by Genette (1980:95) as rare in the literary canon. One of Genette's insights about Proust is that Proust operates almost exclusively with scenes and omissions. For the classical alternation between scene and summary (Labovian narrative in slower or accelerated pace), Proust substitutes an alternation between generic scenes and their instances (Genette 1980:143).

A narrative tends to operate with a given resolution at a time. If resolution is changed, some sort of break in the story is implied. It would be too much to expect nicely nested stories with successively finer levels of resolution, but there is something to the idea as a guiding principle. One reason why children’s stories sound funny is that the granularity is odd from an adult perspective. The stories below are skewed comparing the lengths of the narrative and the events narrated. Such skewings show what the author is interested in.

**Memories of an outing.** I went bathing at Leipäniemi with my class. Lotta had an accident when she bumped together with Simo. She bit her tongue so it hurt. We made autumn hats. All of us had brought things to eat. I had raisins, cookies and juice. I bathed a lot. The water was warm.

**What happened on my holidays.** We were on our way to France. My aunt lives there. We left at 2 pm. We drove to Kuopio airport. There we boarded a propeller plane, which took us to Helsinki and from there to the plane to France. We flew a long time, so long that it was seven pm at night. Then we landed at Paris airport. My aunt’s husband was there to meet us. We started for his car, but we didn’t find the car. We looked for it for an hour, until Philip remembered that it was on another parking lot. At last we were on our way to my aunt’s flat. We were there at two am. First of all we ate. On the following days we just bathed and picked strawberries.

The first story has no story line to talk about: Like Proust, it is an enumeration of the memorable facts about the outing. The second story has a point but the scale is biased.

**Scale**

What is a long time and what short, what is recent and what not, is a function of scale. Time is long or short only comparatively. For instance, the implicature of the progressive as recent, brief, or temporary is not absolute, but at best relative to the corresponding simple tense. As Mittwoch (1988:239) points out, the earth has been turning on its axis for millions of years. Joos (1967:136) notes there is no absolute time-scale inherent in the progressive aspect: its span of validity can be measured in seconds in one social situation, in centuries in another. Everything is relative. Aspect has little to do with measurable duration (Johanson 1998).

A native scale or resolution is built into various event types. A habitual or dispositional event type is inherently longer than a corresponding semelfactive or progressive one. For instance, a sentence like *John slept in his office frequently last fall* cannot be verified for each day so that the truth value sums up for the quarter. Given any fixed value of *frequently*, say *once a week*, there is a minimum resolution for which the claim can be verified. Allowing for averages,
the claim may be true for the semester even in the presence of an exceptional week. Consequently, *John sleeps in his office frequently today* sounds odd.

The present time adverbials that are felicitous with habits are of vague duration, like *now* or *these days*. For a habit to fit the time of speaking does not normally mean that the habit can be restricted precisely at the few seconds an utterance lasts, but rather now is matched to the habit (Jespersen 1924). For instance, when one says *As I am speaking, it rarely rains*, the phrase as *I am speaking* itself assumes coarser granularity, meaning *for the time being* rather than while *I am finishing this sentence*.

Lindestedt (1985:80) notes it is odd to say *At 5 o’clock pm on June 6th, Marko was fond of teaching and learned men*, suggesting that the disposition held only or especially then. Matching events of different granularity is avoided. *Nowadays* is better than *now in*

An aspect shift from, say, progressive to habitual aspect also implies a shift in reference time and granularity. A habitual past easily becomes a remote past of ‘long gone days’: *en used to, ru zhival, byval ‘once upon a time there lived…’*

Conversely, scale influences the interpretation of an event type as actual or generic. If a reference time is in empirical terms too long for the normal duration of an event, then the event will be understood as habitual (Matthews 1987:169).

The result perfect *They have disappeared* of a punctual achievement like *disappear* is taken to refer to a recent event. This is one element of the ‘hot news’ implicature of achievements.

I proposed that point time adverbial vaguely denotes the cycle it introduces (a unit of time in the scale associated with the adverbial). Thus *at noon* means a time around or beginning at noon sharp. *The prime minister will make a speech at noon* has the form speech[noon]. *Max drove out to town at 3* has the form in_drive[town][]3<. *Max drove in to town at 3* has the form out_drive[town][]3<. This explains why *They will build the bridge at 3 next Monday* build[3]<Monday is rather unlikely. There is a difference between *The meeting will be at noon tomorrow and the conference will be at noon tomorrow*. The conference is likely to last longer than noontime, so *start* would sound more believable than *be*.

Mittwoch (1988:238) contrasts

> John was writing a letter/book at 6 pm. 
> John has been writing a letter/book.

Writing a book is too complex and protracted an activity to be completatable at one sitting, which is why the point time adverbial 6pm and the perfect sound odder to her with *book* than with *letter*. Conversely, *John was writing a book when I met him* makes the adverbial when *I met him* temporally vague for her.

Harkness (1987:67) notes that a simplistic ‘just after’ analysis of temporal progression would be in trouble with gaps like

> John came home completely exhausted. He woke up refreshed and saw the problem in a new light.

This is a typical case of granularity. Mittwoch (1988:239) also notes that the requirement for the universal perfect to continue up to the present is subject to granularity, i.e. it allows the exception of an insignificant subinterval immediately preceding the reference point. While sitting in the college refectory, Mittwoch can explain her hoarseness by saying *I have been teaching for 2 hours*, though appreciable time has passed since the lecture. With coarser resolution, the gap can be longer. It can be years in

It is my own share in that tragedy that an early devotion to physics has prevented me from paying any proper attention to Biology until I reached the fifties. C.S. Lewis, *Perelandra*, Ch.7

One of the few attempts at formalising resolution is Hinrichs’ (1981) scoreboard representation for reference points.

There are interesting observations about variation in narrative scale between different types of setting in Pitkänen (forthcoming). Pitkänen classifies narrative settings between subjective (personal), intersubjective (social) and objective (physical) scale types, each with their own favorite vocabulary and spatiotemporal resolution.

**Grounding**

Researchers of languages like Russian which do not have sequence of tense find it more convenient to talk about *foreground* and *background* events instead of events present and past relative to a narrative reference time. Background events are have bearing on the story, but the events related cannot be unambiguously placed on the time line with the foreground events (Leinonen 1982). A backgrounded section may have a different grain to the main story line, because its logical relationship to the main events is not temporal, but, say, explanatory: it provides context, premises on which to base the understanding (i.e. inferences) concerning the main story (Grimes 1975:33-100, Hopper 1979, Longacre/Levinsohn 1978, Wallace 1982).
The question here is what sense to make of the metaphors that background events are ‘outside’, ‘aside’, or ‘behind’ the main story line. One literal sense of this is that the temporal location of a background event in relation to a foreground event is loose or vague: it can be earlier, later, simultaneous, or overlap with it. This is the fact of the matter with open aspect types in general and the perfect aspect in particular.

A somewhat richer interpretation of the background–foreground metaphor might be forthcoming from the notion of resolution (scale and granularity). The same course of events can be split up into sequences of subevents with varying scale (counted in seconds, minutes, hours, days, weeks, months, years), or granularity (leaving out insignificant or eventless bits, thus redefining the contiguity of events, say discounting visits to the bathroom in a romantic novel). In these terms, events in the foreground are told with higher resolution and smaller scale.

The popular but elusive metaphor of (back/fore)grounding in aspect theory can perhaps also be cashed in as a consideration of topic structure. The point of pragmatic ‘grounding’ theories of tense and aspect (Fludernik 1993:201) as contrasted to temporal theories is that aspectual and temporal devices carry structural information about text that goes beyond mere temporal order and constituency of events. The thought is immediate that those further aspects of order concern the logical and argumentative structure of the text.

In my Dialogue Games (1983), I distinguish two types of background-foreground distinctions in discourse, subordination and information structure. Subordination restricts the ability of clauses to act as independent dialogue moves: subordinate clauses can answer questions, supply explanations, or draw inferences only indirectly, by implication. Information structure concerns whether a piece of discourse is old information (repetition) relative to a premise or whether it is new (substitutes for a missing or contrasting piece in a premise). Information structure and subordination between themselves account for a large share of the distinction ‘between presupposed (backgrounded) and asserted (foregrounded) information in discourse.

A good case of a topical analysis of grounding is Gleassey (1998). She notes a contrast between the temporal adverbs at the same time and at the time. The former is foregrounding, the latter backgrounding, as shown by the awkwardness of exchanging the adverbs

Emily climbed Ben Nevis. Sheila was climbing Snowdon at the same time. Fiona was a girl at the time.

Why? Gleassey (1998:108) suggests the answer herself: the same topicalsises times by its contrast with different. Thus the topic structure induced by at the same time is What happened at which time? What time did Emily climb Ben Nevis? What time did Sheila climb Snowdon? which puts the two events on the same footing as parallel answers to the same topic. In contrast, the anaphoric adverbial at the time can make an addition to the topic of Emily's climb (addressed to the topic What was it like then?). Meanwhile can be paired with at the same time and then with at the time in this respects.

Gleassey (1998:113) also explains how it is that topic structure constrains aspect here: in order for two sentences to answer the same question of a given event type, they have to entail comparable events of that event type. Being a girl is not a feat parallel to climbing Ben Nevis when the topic is Who did what in?

To put the question more generally: what is the connection between choices of tense and aspect and topic structure? There is not likely to be any one simple answer here, for topic structures come in endless variety (Dry 1981, 1983, Fludernik 1993). But there are tendencies, just as there are tendencies for certain topic structures over others. One way to approach this question is to catalogue frequent types of aspect shift and correlate them with associated topic shifts.

**Topic shifts**

Points of tense and aspect shift are particularly revealing for the referential and entailment relationships between different tenses and aspects in discourse. These shifts can be analysed in terms of topic structure: what questions are addressed (How did it happen? Why did it happen? What does that prove?) Here is a collection of cases:

**From present to perfect**

The perfect explains the present. The discourse is about the present. The past event is mentioned but not narrated.

Ona znajet o tom, chto vas pervovdjet na Minśk? Da, ja ej pisala. ‘Does she know that you are being transferred to Minsk? Yes, I’ve written (ipf) to her.’

Moja kartochka v poliklinike dolzhna byt’. Ja zapisyvalsja v proshlom godu. ‘My card must be at the clinic. I registered (ipf) last year.’

Kakie u nas neudobnyje mesta! Kto pokupal ix? ‘What bad seats we’ve got! Who bought (ipf) the tickets?’

Daet znat’ sebja vlijanie rannego Anri Roshfora. Davno perechityvali? ‘One can recognize the influence of early Henri Rochefort. Is it long since you reread (ipf) it?’

**From perfect to simple past**

...
An event introduced with a perfect is taken up for discussion by a simple past.

…you will kindly tell me what has happened, when it happened, how it happened, and what Dr. H. has to do with it.

‘I believe we’ve met somewhere before, Mr. Buchanan.’ ‘Oh yes, said Tom, gruffly polite, but obviously not remembering. ‘So we did. I remember very well.’ ‘About two weeks ago.’ ‘That’s right. You were with Nick here.’

It has been my experience, whenever I have sought for counsel on light verse, that the friend to whom I have been speaking has said: “The best light verse that was ever written was done by Robinson-Smith” - or some such name. “And where”, I have asked, “is it to be found?” “It has never been republished”, he replied. “It was in the pages of an old college magazine, or the Wigan Times”. “But Robinson-Smith himself may have copies of those numbers?” I pursued eagerly. (Zandvoort 1931:116, Hirtle 1975:73)

“You have killed a man. We must go away.”… “I was attacked”, Kino said uneasily. “I struck to save my life.” … “Do you think your explanation will help?”

From pluperfect to simple past
Here, a flashback is initially framed with a pluperfect but the story itself is retold in the simple past.
Languages rarely have means for sustained narrative in past twice removed (Johanson 1998:§8.3).

McGraw told me he had sent a pair of his dicks (…) to see the girl that morning, to see how much help she could and would give the department in copping Whisper for Noonan’s murder. The dicks got to her house at nine thirty. The front door was ajar. Nobody answered their ringing. They went in and found the girl lying on her back in the dining room, dead, with a stab wound in her left breast. (Hammett, Red Harvest, Cowper-Kuhlen 1987:25)

I was sent to the Damenstift to be educated when I was fourteen years old and had been there for four years. During that time I had been home to England only once, which was when my mother had died. My two aunts had then come to look after my father and I disliked them from the first because they were so different from my mother. (Victoria Holt, One the Night of the Seventh Moon).

One autumn night, five years before, they had been walking down the street when the leaves were falling, and they came to a place where there were no trees and the sidewalk was white with moonlight. They stopped here and turned toward each other.

From imperfective to perfective

The forms of suffixal pluperfect and perfect fall together in third person plural in Portuguese.
A shift from imperfective to perfective in aspect languages marks an analogous shift from *discours* to *récit* in aspect languages. An event introduced with an unmarked imperfective is taken up for discussion with a perfective.


‘Have you kissed (ipf) anybody’s hand? - My grandmother’s, in early childhood. Mother made (pf) me.’

**ru** Skazhi, ty tozhe podpisyal bumagu o tom, chto mozno stroit’ na Kachalovskoj? - Podpisival. - Pochemu zhe ty vse-taki podpisal?

‘Say, have (ipf) you too signed the paper affirming that they could build on the Kachalovskaja? - I have (ipf). - Why did (pf) you sign it?’

**bg** Vizda li se s nego sled onaja nost? Vizdax go. Snosti go vidjaj tam.

‘Did you see/have you seen him (aor ipf) after that night? I did/have (aor ipf). I saw (aor pf) him there last night.’

The next batch instantiates a generalisation in the imperfective with individual events in the perfective.

He was feeling (could feel?) once again the effect of the radiation which did not belong to the atmosphere that surrounded the planets. He felt the familiar lightness of heart… (back translation, check original! C.S.Lewis: )

**pt** 'Sentiu no corpo mais uma vez o efeito de radições que não faziam parte da atmosfera que envolve os planetas. Sentiu a já conhecida ligeireza no coração…’

**bg** A pak az. ziveja, taka da se kaze, s vsicki tezi sabitija. Zabudja se nostem, a v glavata mi vse tova…

‘Zapalja cigarra, podpra se na vazglavnicata i prodalzhavam da si mislia.

‘But I live (pres ipf), in a way, with all these events. I will wake (pres pf) in the night, and it is still all in my head … I will light (pres pf) a cigarette, lean (pres pf) on the pillow, and I keep on thinking (pres ipf).’

**ru** Prosto zabodit muzyku poslushat’. Sjadjet v ugol, poslushajet chasok - i domoi.

‘He simply drops by (ipf) to listen to music. He will sit down (pf) in a corner, listen (pf) for a while and home (he goes).’

**ru** Nazvyajet ego raznymi xamskimi imenami. V grud’ pixaet. Pixnet i govorit …

‘He calls (ipf) him various rude names. He pushes (ipf) him in the chest. He will give (pf) him a shove and say (ipf)…’

**From perfective to imperfective**

Here, a perfective event is described in manner by the activities that cause it:

**bg** Zatvornikat e napisal dva lozunga nad vrata na kilijata. Pisl e s ostro kamaace.

‘The prisoner has written (perf pf) two slogans above the door of the cell. He wrote (perf ipf) them with a small sharp stone.

**bg** Toj xodi cjaj den. Slizashe v dalboki dolove, varveshe pod klonite na stari buki i stari dabove…

‘He walked (aor ipf) for the whole day. He descended (impf ipf) to deep valleys, walked (impf pf) under the branches of old beeches and old oaks.’

**ru** V etoj portornoj ja obdumyval svoju dissertaciju i napisal pervoje ljubovnoje pis’mo k Vere. Pisol karanashom.

‘In this tavern I pondered (ipf) about my thesis and wrote (pf) my first love letter to Vera. I wrote (ipf) it in pencil.

**ru** Tshto i govorit’, eto bylo ne samejo obrazcovoje otdelenije. Proderzhkali nas tam minut sorok - kuda to zvonili, vyjasnili, trebovali fotoplenku i tol’ko posle aktivnych nashykh ubezhdenij … i dopolnitelnykh svonkov nas ostupili i dazhe izvinilis’.

‘I must say it wasn’t a model police-station. They held (pf) us there for about forty minutes - they made (ipf) phone calls, asked (ipf) questions, demanded (ipf) the film from the camera. And it was only after our active persuasion … and further phone calls that they let (pf) us go, and even apologised (pf).’

**pt** ‘…Kino viu, ao seu lado, Joana levantar-se sem ruído e aproximar-se da fornalha. *Movia*-se tão cuidadosamente que só quando afastou a pedra do lar Kino a ouviu fazer um levíssimo rumor.’

He saw (pf) her move toward the fireplace. So carefully did she work (ipf) that he heard only the lightest sound when she moved the fireplace stone.

**pt** No oitavo dia ele começou a falar em voz alta. - É justo, meu Deus! dizia ele repetidamente. … Depois voltava subitamente à questão da comida que eu não lhe dava. …
‘On the eighth day he began (pf) to talk aloud. ‘It is right, my God!, he said (ipf) repeatedly. … Then he suddenly returned (ipf) to the question of the food he did not give (ipf) him …

Players

Narratologists disagree about the best linguistic metaphor for the point of view *par excellence* in literature theory: the choice of the player whose propositional attitudes (knowledge, belief, perception, preferences, plans) are revealed in a narrative. Todorov titles it *aspect*; Genette divides it under *mood* and *voice*, though *person* obviously has to do with the matter as well (Genette 1988:§15-16). Mood concerns both "who sees": whose access to the events is reflected by each move in the narrative, and "who is seen": who the story is about: who are the main characters of the story, whose identity is the theme of the narrative (Carlson 1983). *Voice* concerns "who talks": the relation of indices of the fictive narration situation (time, place, author, addressee, audience) to the the times, places, and participants appearing in the story. At the extremes are first-person autobiography (first person on all counts, Genette 1983:107) and an encyclopedia (impersonal on all counts).

It is a built in feature of dialogue game theory that language games are many-player games of imperfect information. The assumption of standard game theory that players have full common understanding of the structure of the game is an idealisation. In reality, all players in a dialogue game must, and do, keep their own books on what is happening in the game, and can only assess the situation from their subjective point of view.

An immediate consequence is that propositional attitudes in a dialogue game iterate: there is not only what really happens (Nature's moves), but what each player *thinks* happens, has happened, or will happen, what they *want* to happen, what they think the others think, want, and so on ad libitum. A related narratological notion is Genette's *level* of narration, which starts from the outermost fictive narration situation and iterates into embedded stories told by characters on each level.

A subjective point of view on what happens is what characterises *fiction*. A crucial point about fiction seems to be that it involves someone's *experience*, events from a *character's subjective point of view*, rather than an objective, impartial view of events. Reader's Digest turns real life accident reports into fiction (from the consumer’s point of view) by adding the victims’ viewpoints. It is irrelevant whether events similar to the fiction have happened. *Realism* in fiction is not about factual truth; rather realism has to do with the extent to which the choice of events described reflects some particular subject's interests in the game:

> The loud-sounding shore [in Homer] serves no purpose other than to let us understand that the narrative mentions it only *because it is there*, and because the narrator, abdicating his function of choosing and directing the narrative, allows himself to be governed by "reality", by the presence of what is there and what demands to be "shown." A useless and contingent detail, it is the medium par excellence of the referential illusion… (Genette 1980:165)

Minimally, fiction describes *how life would appear to somebody in some situation*. This, then, is one of the standing topical questions in a novel (in any narrative, in fact), one which can be raised at any point: *What did they think/feel about it?* According to the deictic shift theory (ref) reader places himself (*I, here, now*) in the story. Readers *identify* themselves with a character. They feel or imagine what a character feels and perceives. This could be the definition of identification or empathy with a character (Kuno 1977).

From the dialogue game point of view, stories are plays of n-person games. In a traditional story with a plot, there is an initial setting, a conflict, and a resolution. The conflict sets things in motion, a problem for some character(s) to overcome, or a fight between characters to settle. Modern novels may rather resemble iterated games where there is no designated initial situation or outcome; no heroes or villains, winners or losers.

As in n-person games in general, it is very important to keep track on who knows (perceives) what, who wants (thinks) what, and who is able to do and does what, in particular, which player the reader is supposed to be teaming with at each stage. The kind of partial identification that takes place in reading resembles what happens in n-person games: a bridge team has partial information about one another, coalitions in bargaining games have partly convergent aims. Just as in n-person games, much of the interest and suspense comes from different players - including the reader - knowing different things about the game to start with, while a fuller picture gets revealed bit by bit to them and to the readers.

A distinguishing feature of a full blown novel seems to be this symphonic structure, alternating development of different points of view. A novel is a system of narratives which have some common aims. This justifies the novelistic strategy of starting a new chapter without immediately joining it to the foregoing one(s), just as a symphony can add a new motif which only later joins the rest.

A full analysis of temporal structure in a novel would: 1) describe the possible reconstructions of the the stories behind the narrative 2) show how the story has been topicalised and linearised and why - for instance, what is told when, and why just then 3) show what clues the reader is given to infer the structure 4) how informative and reliable the clues are - what background assumptions are needed to reconstruct any one of the proposed underlying structures. TMA devices are an important source of such clues.
Récit
Tenses has been associated to discourse type in the European literary tradition represented by Benveniste (1966) for French and Weinrich (1964) for German (Fleischman 1990, Leinonen 1996). The tenses of besprechen, discours (conversation) engage the speech participants immediately and concern the speech situation. With these forms, (present, present perfect, future) the speaker acts, while the hearer has to react, adopt an attitude (Weinrich 1964:50-55). For instance, the (German) present perfect is “das Tempus der subjektiven Feststellung oder Meinungsausserung” (Weinrich 1964:80). The tenses of erzählen, histoire (récit, narration) remove the speaker and the hearer from the actual speech situation, they do not demand any reaction from the hearer or bind the speaker for action (preterit, pluperfect).

The difference between discours and récit thus concerns deixis. Discours is marked by proximal deictics: the here and now of the actual dialogue situation, the narration situation, and its primary participants I and you. Recit is marked by distal deictics and anaphoric third person references which refer to narrated situations in the story.

A simplistic classification of discourse types can in fact be based on cross-tabulating first, second, and third person references with present, past, or future tenses.

<table>
<thead>
<tr>
<th>persons</th>
<th>past</th>
<th>extended now</th>
<th>future</th>
<th>any</th>
</tr>
</thead>
<tbody>
<tr>
<td>me (and others)</td>
<td>autobiography</td>
<td>resume, annual review</td>
<td>promise, threat</td>
<td>opinion, announcement</td>
</tr>
<tr>
<td>you (and others)</td>
<td>reminder</td>
<td>accusation, praise</td>
<td>order, instruction</td>
<td>judgment</td>
</tr>
<tr>
<td>you and me (and others)</td>
<td>reminiscence</td>
<td>exhortation</td>
<td>proposal, negotiation</td>
<td>conversation, debate</td>
</tr>
<tr>
<td>others (only)</td>
<td>legend, history</td>
<td>survey, review</td>
<td>forecast, directive</td>
<td>theory, law</td>
</tr>
<tr>
<td>any</td>
<td>narrative, story</td>
<td>report, explanation</td>
<td>plan</td>
<td>description, argumentation</td>
</tr>
</tbody>
</table>

Table 49
These assignments are only illustrative. Genres participate in many semantic fields with different prototypes and peripheral cases depending on the field.

For written discourse, the external narration situation is an event type consisting of distributed event tokens of writing and reading of the text. Proximal deictics in writing correspondingly have multiple reference: Now that I write this is not now that you (yes, I mean you) read it. The common denominator is the textual here and now at a point of the narrative. (One asks where one is in a story, not when.)

Fiction is discourse that does not denote an actual situation. More than that, there is an open common understanding that fictive discourse, true or not, does not denote. Tax returns or politics are false but not fiction. Children’s make believe (I am mom and you are dad and this is our house) is fiction. In fiction, even deictics may fail to denote. This causes the separation between author and narrator (first person denotation) in fiction (Genette 1980:213). Other deictics are separated in the same way: now in fiction is a fictitious now. As Genette (1980:224) notes, the fictitious now of a past narrativeneed have no duration, whatever time the actual narrative may take in writing or reading.

Deixis in fiction
There are well known exceptions to the straightforward association of proximal deixis with discours and distal deixis with récit, both ways: historical present on the first count, and free indirect discourse on the second. One thing in common to both is that proximal deictics do not denote the narration situation, but temporal and epistemic alternatives to it (narrated situations). It follows that the means for referring to the narration situation are at least partially lost, bracketing off the narrative from the narration.

A typical example of shifted temporal deixis is

Now I was there.

It is time that shifts in a narrative, not place. I was here really means this here, not the scene of the story. We do not find Now I was here meaning a place where I am not now, or I am there then talking about a past time.
Why is it that time shifts but time does not? The obvious difference that there are two times in the sentence, the adverb and the tense, but only one place. With two times now and then, there are two of I as well: I now, the narrator, and I then the protagonist. That makes sense, because I am a function of time. Let us use some formalism. From the section on demonstratives, we have

\[
\text{now} = t: I \text{ at } t \quad \text{then} = t: I \text{ not at } t \quad \text{here} = p: I \text{ at } p \quad \text{there} = p: I \text{ not at } p
\]

The event type was \( e:e<\text{now} \) is equivalent with then \( t:t<\text{now} \): the words are synonymous in event calculus.

\( \text{Now I was there} \) is word by word the event type

\[
\text{now I was there} = (at t: I \text{ at } t) I (at t: I \text{ not at } t) (at p: I \text{ not at } p)
\]

Multiplying the tense into the event type, we get

\[
(at t: I \text{ then at } t) I \text{ then} (at t: I \text{ not at } t) (at p: I \text{ not at } p)
\]

This is an algebraic counterpart of letting was bind now. In scope terms, the time adverb is scoped and bound by the tense, while tense stays transparent (indexical). \( \text{Now is not temporally transparent here} \) (Kamp 1971).

A prediction of this account is that a shifted proximal deictic needs another distal deictic to shift it. This explains why place does not shift in \( \text{I was here} \). Note the following colloquial usage::

When he got there he thought here \( I \) like I \( \text{ here/there was a place he liked} \).

All or any of the deictics can remain in quotation form, but there is an order of priority: \( \text{there was a place I liked} \) won’t say the same. Compare

When I was \( \text{here} \) last I liked it \( \text{there} \).

\( \text{There is literally excluded if there is defined as not here} \). This is relative to dialogue, like I don’t call me \( \text{he or you she} \) (see section on deixis). Check also \( \text{shortest access principle} \) in Carlson (1988).

**Running commentary vs. blow by blow report**

In a narrative we go to an earlier scene. It is the opposite of a play, where the scene is here and now. Joos (1967:128ff) has constructed texts to illustrate differences between different types of present tense report. A **running commentary** narrates events while they are in progress. The narration situation keeps in step with and framed by the narrated situation.

Superintendent Hannam is examining the cupboard. Behind his back the Doctor is watching him. He seems to think that the superintendent won’t notice what he is doing. He is starting to walk slowly across the room. Ah, I see: there is another built-in cupboard on the left-hand side of the fireplace. Now the Doctor is opening the centre compartment and putting his hand inside. I’m afraid that the superintendent is watching after all and can see what I see: the Doctor is taking out a couple of things and putting them inside his left-hand jacket pocket.

To transpose running commentary to a past narrative, Joos (1967:127) states a rule for narrative progression: “Every generic aspect of here-and-now reference remains generic with real past reference; but the temporary aspect is changed to generic aspect for each event that advances the plot of the narrative and remains temporary for each event that is rather background to the plot-advancing events without itself advancing the plot.” This rule produces

While Superintendent Hannam was examining the cupboard, the Doctor walked slowly across the room to an identical built-in cupboard on the left-hand side of the fireplace, opened the centre compartment and put his hand inside, then he took out two objects which he put inside his left-hand pocket.

The difference is one of perspective: the running commentary moves time forward in small installments, telling what is happening around each independently selected reference time. The blow-by-blow account moves time forward with the successive events, disregarding times in between. The topical questions differ accordingly: \( \text{What is going on now? vs. What happens next?} \) Another example from Joos:

I’ afraid I don’t quite realize what is happening. There seems to be a kind of exercise-book. Now it has gone from counsel to the usher, and now it’s in front of Nurse Stronach. She is beginning to turn the pages. Nothing much seems to be happening. Well, the Attorney-General is on his feet but hasn’t said anything; the national Press have leapt their box and are massing by the door. Mr. Lawernce is hanging fire. Nurse Stronach is reading. Nobody is paying the slightest attention to the Doctor in the dock. Now the Judge is speaking to Mr.Lawrence.
Before anyone quite realized what was happening, there was somewhere a kind of exercise-book and it had gone from counsel to the usher and was then in front of Nurse Stronach, who at once began to turn the pages. There was a hovering interval during which the Attorney-General was on his feet but had not said anything; the national Press had leapt their box and were massing by the door. Mr. Lawrence hung fire and Nurse Stronach was reading. Nobody paid the slightest attention to the Doctor in the dock. Then the Judge said, Mr. Lawrence, is this one of the exhibits in the case?"

The eyewitness commentary moves reference time (now) ahead little by little by successive snapshots of states. The narrative version the story moves forward with and then by successive changes. Note the differential treatment of read and hang fire. The nurse is engaged in an activity, Mr. Lawrence forbears an act (keeps quiet for the while).

A special case of eyewitness commentary is the Portuguese use of imperfect in dream sequences. All events are reported as taking place round a specious present of the dream.

Ela sonhava que uma das nuvens brancas que passavam pelo céu anilado, roçando a ponta dos rochedos, se abria de repente e um homem vinha cair a seus pés, timido e suplicante. Com o seio palpitante, toda trêmula e ao mesmo tempo contente e feliz, abria os olhos; mas voltava-os com desgosto, porque, em vez do lindo cavalheiro que ela sonhara, via a seus pés um selvagem.

'She was dreaming that one of the white clouds which were passing across the indigo sky, brushing against the top of the cliffs., was opening suddenly, and a man was falling at her feet, timid and supplicant. Her breast palpitating, trembling and at the same time content and happy, she was opening her eyes; but was turning them away in disgust, for, instead of the beautiful cavalier that she had been dreaming of, she was seeing at her feet a savage.' José de Alencara: O Guarani, Ch. V.

**Historical present**

Aspect modifies event type and tense relates the event time to a reference time. The simple present is the simplest tense, an identity operation, on both counts. In this sense, historical present (Brugmann 1913:733, Noreen 1904-12:677), defined as use of present tense in an account of past events, does even less than an indexical present. It lets the successive events use themselves as their own index instead of relating them to the time of speaking. It is a dramatical present (Jespersen 1924:258) playing back events in the past like in a play (Langacker 1982:290, Klein 1994:134ff).

Vatel attend quelque temps: les autres pourvoyeurs ne vinrent point, sa tête s’échauffait, il crut qu’il n’y aurait point d’autre marée. Il trouva Gourville; Gourville se moqua de lui. Vatel monte à sa chambre, met son épée contre la porte, et sse la passé au travers du Coeur; mais ce ne fut qu’au troisième coup (car il s’en donna deux qui n’étaient pas mortels) qu’il tomba mort. Cependant la marée arrive de tous côtés; on cherche Vatel pour la distribuer; on va à sa chambre, on heurte, on enonce la porte, on le trouve noyé dans son sang. (Mme de Sevigné, cited in Guillaume 1929:61).

Historical present is only a special case of fictive use of tenses, and in that respect no different from fictive past. The fictive now of narrative fiction has no relation to the real time of reading or writing. The main difference between fictive present and fictive past that in past narrative, the fictive now does not shift with the events described, which leaves the author more room of shifting by blow accounts either: habitual and generic present tense fiction exists as well. 149

It is not only the simple present that is subject to dramatical use, but the whole tense system is subject to the shift, or rather, lack of it (Ikola 1949, Declerck 1997):

As usual, there is somebody waiting to see her, standing by the door. When she gets closer she sees that it is Vic Wilcox: she didn’t recognise him immediately because he is not wearing his usual dark business suit, but a short-sleeved knitted shirt and neatly pressed light-weight trousers. (Declerck 1997:71)

Aspect depends on perspective: whether the bounds of the event are outside of the specious present of the narrative (running commentary) or inside it (blow by blow). 150 According to Joos (1967:131), historical present is characterised by the narrative use of aspects. Changing just the past tenses of the above narratives to the present produces a historical present narrative indistinguishable from a blow-by-blow report or stage script, for the events are timed by themselves, not by observation times inside them:

While Superintendent Hannam is examining the cupboard, the Doctor walks slowly across the room to an identical built-in cupboard on the left-hand side of the fireplace, opens the centre compartment and puts his hand inside, then he takes out two objects which he puts inside his left-hand pocket.

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149A recent example is the novel Marsipansoldaten by Ulla-Lena Lundberg, Söderströms 2000.

150Cf. Lindstedt (1985:139): “present time reference is inherently non-closed (imperfective) in all languages, except when the point of speech moves along an anticipated series of events”.
Before anyone quite realizes what is happening, there is somewhere a kind of exercise-book and it has gone from counsel to the usher and is now in front of Nurse Stronach, who at once begins to turn the pages. There is a hovering interval during which the Attorney-General is on his feet but has not said anything; the national Press have leapt their box and are massing by the door. Mr. Lawrence hangs fire and Nurse Stronach is reading. Nobody pays the slightest attention to the Doctor in the dock. Then the Judge says, Mr. Lawrence, is this one of the exhibits in the case?"

Recall the analogy between demonstratives and near and remote tenses. From this point of view, the historical present takes a narrative as near the story as possible, at the price of losing reference to the actual present. It gives the feeling of being brought in the middle of the past events. The feeling is not really essential for historical present. It comes from applying the indexical entailments of the simple present to historical present. We must place ourselves in the past when we can’t place the events relative to the point of narration.

First and second person references This person comes up to me and asks if I have seen you around in historical present have a conversational feel because there is no separation of the narration and the narrative, the speech event and the event described. Historical present is an established oral narrative discourse type (Schiffrin 1981, Wolfson 1982, Myhill 1992:62). It is a common literary device in many written cultures. It is common in Slavic languages (Lindstedt 1985:23). There could be a connection between historical present and quotative sequence of tense.

From a formal point of view, historical present is straightforward. The present is formalised as usual. The difference only concerns the denotation of now. Cooper (1986:31) states it as a rhetorical rule for shifting the here and now of the discourse location (narration situation):

> Rhetorical relocation: Relate the discourse location to some past location.

This means that now does not always denote time of narration, that is just the default. Nor, obviously, do occurrences of now in successive sentences have to keep denoting the same moment, in actual any more than dramatic present.

Here is what happened. I am at the library and this guy comes up to me. happen\[then<now A library\]now2\[then A come\]now2

A variant of historical present is what Brugmann (1913:736) calls praesens annalisticum, distinguished by the presence of past time date expressions, and found in numerations of historical events (Delbrück 1897:263, Wackernagel 1920:165). This comes close to the uses of space-time metonymy in citations and summaries (praesens referens or auctoris, Siro 1949).

**Free indirect speech**

Dramatical tense can be contrasted to use of indexicals in the style known as free indirect speech/discourse (discours/style indirect libre, erlebte Rede, Lips 1926). Free indirect speech is a narrative style describing events from the perspective of one or more of the narrative participants, reflecting more or less directly the form and content of their thoughts or inner speech (Fludernik 1993), but replacing some character related proximal deictics (including present tense151) with narrator related distal ones. This is a style, not grammar (Authiers 1979, Vett 1992:62). It is a common literary device in many written cultures. It is common in Slavic languages (Lindstedt 1985:23).

Free indirect speech gets a detached, literary feel to it when the here and now of the narration event, including the author and audience, are left entirely unmentioned. When they are mentioned, free indirect speech reveals itself as a variety of quoted speech:

> I talked to John this morning. He was a different person now. You had taught him a lesson. He would never fail us again.

Prevented by the indexical pronouns (I, you) from identifying with John, we construe the account as a report of John's words, as if he said was missing. Now denotes John's speech event: now2: different\[now2\]then<now As the mixed deictics now2\[then show, free indirect speech characteristically mixes anaphoric references with deictic ones.

Different variants of free indirect speech are obtained by different mixes of indexical expressions with anaphoric ones, from personal pronouns (I am tired/he was tired), tenses (I will do it/she would do it), aspects (she worked fast/she was working/had worked fast) demonstratives (She was angry now/then, here/there she was, this/that was odd), to perspectival vocabulary (she went/came in, she felt/looked tired). A sure sign of free indirect speech is the occurrence of

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151 Fludernik (1993:91) points out that past tense shift is actually a relatively recent stylistic feature in free indirect speech.
main clause bound past futures (would) with speech time adverbials today, tomorrow, next week (Huddleston 1967:788, Banfield 1981).

More generally, free indirect speech makes observations, expresses attitudes and uses wordings that can only be ascribed to the subject of the free indirect speech. This was awful. She felt panicky. She would never make it. Her heart pounded, her hands were cold and sweaty. How could she ever have agreed to do this. But it was too late to turn back now. Damn it. She would show them, by God she would.

Kamp and Rohrer (1983:266) distinguish in French between temporal perspective (a back shifted perspective of an onlooker) which allows past use of certain proximal temporal adverbials like maintenant or dans six heures, and personal perspective (the perspective of a character in the story) which allows past reference with aujourd'hui, demain, hier. The former can be ascribed to the narrator; only the latter imply free indirect speech proper (Vetters 1994). Their crucial example is the following.

Le capomafia alla tranquille au lit à minuit. Il ne se doutait pas/savait bien qu’il se couchait sur une bombe qui exploserait dans six heures/demain. ‘The capomafia went calmly to bed at midnight. He did not suspect/was aware that he slept on a bomb that would explode in six hours/tomorrow.’

Demain only goes in the personal perspective created by savait bien, not the temporal perspective created by ne se doutait pas. If the second sentence is framed relative to point of speech using passé simple, only plus tard will do: Le bombe explosa 6 heures plus tard.

Temporal perspective is simply an instance of the use of proximal deictics to refer to objects, places and times the author (narrator) is speaking about now (‘at this point in the story’), e.g. Weldon’s She weeps here describing a tape recording. It occurs in entirely impersonal stories with no protagonists at hand. Finnish has a proximal time adverbial tällöin ‘at this time’ which can only be used for temporal perspective. It is not used indexically or in free indirect speech.

Perception events and narrative progression

Literary technique revolves around the presentation of points of view. Varieties known as direct, indirect and summarised speech (thought), subsumed under the misleading rubric of mood in Genette (1980:§4) have grammatical reflexes in the phenomena sequence of tenses (bound tense and aspect) and the use of deictics.

The standing question What was it like then? following a sequence of events can be approached from a particular angle, the point of view or perspective of some particular character P, narrowing it down to the question What was it like to P then? This makes the structure of some narratives comparable to a camera script: action sequences, stills, scenes, cuts, flashbacks, fadeouts, commentaries, always from some particular angle. Dowty (1986) points out that in the story

Mary entered the president’s office. A copy of the budget was on the president’s desk. The president’s financial advisor stood beside it. The president sat regarding both admiringly. The advisor spoke.

we do not only assume that the states described in the midmost three sentences began to obtain before Mary’s entry, but also that they bridge the time between Mary’s entry and the time of the accomplishment that ends the passage. The advisor spoke. The phenomenon prompts Dowty to generalise narrative progression to states: “there would be no reason not to assign very brief and closely spaced reference times to stative sentences”, despite the fact that we do not perceive that time “moves” in these sentences.

Instead, I prefer to follow Dowty’s own advice (1986:50) and look at the implicit questions addressed by the discourse. The question answered by the three stative sentences is What was it like to Mary in the office?, specifically, What did Mary see in the office? The next three sentences can be taken as answering both questions: the explicit discourse structure is a list (What else was there?), while Mary’s observations form a temporal sequence (What did Mary notice next?). The last sentence again addresses the question What happened next?

Schopf (1989:262) too allows perceptual or propositional acts to move the story forward if and only if they are a subject of the narration, variously known as the flow of consciousness technique, indirect free thought, substitutionary perception, or interior monologue. Example from Jespersen (1949:§14.9.5):

She heard the car draw up to the gate of their garden. He was coming up the stairs. He came into the room. Her heart was beating wildly and her hands were shaking; it was lucky she lay on the sofa. She was holding an open book as though she had been reading. He stood for an instant on the threshold and their eyes met.

The following reconstruction is compatible with the tenses and our background knowledge about similar scenes. She hears the car; a little later she hears him coming in the stairs (prog); soon afterward she sees him come in (simple); at the same time (prog), she feels signs of strong emotion. Switching to the man’s perspective, he sees her feigning reading (prog). Finally we are shown them both in the same scene looking at one another (simple). One can imagine how the same sequence could be cut into film. The progressive form indicates that a reference time must be
reconstructed in the context (by interpolating the right topical questions); the reference time need not be there explicitly. This point is often missed in discussions of narrative progression.

Another instance is Cowper-Kuhlen’s (1987:21)

I sipped my drink and nodded. The pulse in his lean grey throat throbbed visibly and yet so slowly that it was hardly a pulse at all. An old man two-thirds dead and still determined to believe he could take it. ‘Your conclusions?’, he asked suddenly. Chandler, The Big Sleep.

The substitutionary perception (Fehr 1938, Leech/Short 1981) of the pulse and the evaluation of the man mark time and drag the story forward if ever so slowly, though the events observed are in themselves open and overlap with the foreground events. (This might be an instance of Genette’s missing tempo of slow motion.)

**Picturesque imperfective**

There is i a well known narrative figure which combines a progressive form with a bounding or location time adverbial, known variously as narrative or picturesque imperfective (Vet and Molendijk 1986, Waugh 1990) or imperfect of rupture (Tasmovski-De Ryck 1985, Smith 1991, Pollak 1960:145-151, Johanson 1998:§7.2.3). Though a lot can said of it as a stylistic device, there is nothing out of the ordinary about its temporal logic: the time adverbial sets a time, and the event wraps around it as usual.

Commenting on the use of the English progressive to move events forward in narration, Poutsma (1921:59) observes that it imparts vividness to the scene; cf. also Jespersen (1949:§12.6.5), Fludernik (1993:204ff). Dowty (1986:55) for one observes that a picturesque imperfective does not denote a change. Rather the message is that an event has begun to happen, and it is only after it is already in progress that we are told what is going on.

Mr Darby slapped his forehead, then collected himself and opened the door again. The brush man was smiling at him hesitantly. (Hinrichs 1986:69)

Most commonly, there is an explicit point adverbial of the type of suddenly, the next thing she knew, soon. Obviously, it is the adverbial which sets the clock ahead here.

In the darkness, John felt his way up the stairway of the dilapidated old house. Halfway up, there was a loud cracking noise under his feet, and suddenly he was falling through space.

Where’s Mr Luttrell? he heard her ask. In a moment she was greeting him…

Manning shook off his early Evangelical considerations, started an active correspondence with Newman, and was soon working for the new cause.

Vinay and Darbelnet (1975:§117) describe the phenomenon in French:

Le cinéma fournit un moyen commode de rendre compte de l’imparfait. Quand les images se succèdent sur l’écran, il y a narration et par conséquent, si nous transposons dans l’écriture, nous aurons, l’action se situant dans le passé, l’un des deux temps passés de la narration, le passé simple ou le passé composé. Mais si le metteur en scène s’attarde sur une image, si celle-ci reste à l’écran sans que rien de nouveau se produise, si elle s’agrandit pour mieux voir certains détails, alors notre transposition écrite sera à l’imparfait. Ce sera set imparfait affectif don’t les grammaires ne parlent pas toujours e qui a pour l’effet de rendre la scene plus frappante: Une heure après le cabinet remettait sa démission. L’écart entre le présent e le passé est aboli, nous sommes plongés dans le passé comme si c’était le présent. D’où le caractère dramatique de cet imparfait.

Smith (1991:131) provides examples:

fr Elle résolut de le porter elle-même à Honfleur. Les pommiers sans feuilles se succédaient au bord de la route.

‘She decided (pf) to take it herself to Honfleur. There were apple trees without leaves lining (ipf) the highway.’

fr Il me sourit et me tendit la main. … avant de sortir, Armand prit une lettre fort apaisée, adressée à son père, et confiante sans doute de ses impressions de la nuit. Une demi-heure après nous arrivions à Montmartre.

‘He smiled (pf) at me and gave (pf) me his hand … before leaving, Armand took (pf) a thick letter, addressed to his father, which no doubt confided his impressions of the night. An hour later we arrived (ipf) at Montmartre.

In the beginning of a narrative, an imparfait pittoresque locates the reader in the middle of the events (Lerch 1922, Pollak 1960, cf. section on perception in narratives). Note the concomitant perceptual vocabulary (sombre ‘dark’).
Le 4 septembre 1768, naissait à Saint-Malo, dans la sombre rue des Juifs, le chevalier François de Chateaubriand.

'On September 4, 1768, F.d.C. was born (ipf) on the dark street of rue des Juifs.'

Due secoli fa nasceva a Bonn L. Beethoven. 'Two centuries later, in Bonn, L. Beethoven was (ipf) born.'

Sarandapendene xronia prin, s’ena nosokomio, ksepsixuse enas Iskios, arrostos ke perifivos ke monos. '45 years earlier, in a hospital, a Shadow passed away (ipf), sick, frightened and alone.' (Hedin 1998)

Imparfait de rupture/narratif constitutes a common way end an episode in an unexpected or significant turn of events (Fludernik 1993:203). The form is usually accompanied by a location time adverbial that shifts narrative time forward.

Comme elle avait été à l’Opéra, une nuit d’hiver, elle rentra toute frissonnante de froid. Le lendemain elle toussait. Huit jours plus tard elle mourait d’une fluxion de poitrine.

'As she had been to the Opera one winter night, she returned (ps) home completely shivering with cold. The next day she was coughing (ipf). A week later she was (already) dying/died (ipf) of pneumonia.'

Un mois plus tard, elle signait le contrat de vente et achetait en même temps une petite maison bourgeoise. 'A month later she was signing/signed (ipf) the sales contract and was buying/bought (ipf) at the same time a small house.'

This type of "imparfait of final consequence" is suited to the task of finishing a sequence of events because unlike perfective, imperfective does not raise the question and what happened then? There is a suggestion of immediacy and narrative presence due 'zooming in' the time scale (Irandoust 1994:85) involved too. (Recall that imparfait allows déjà ‘already’.)

Portuguese grammars also mention a specific use of the imperfective called pitoresco where a sudden event is portrayed in progress (Santos 1996:360, Sten 1973:99ff), reminiscent of a film cutting into the middle of a new scene.

- **pt** Momentos depois, assomava à porta da biblioteca.
  ‘Moments later, he appeared (was peeping in) at the door of the library.’

- **pt** 'Um momento mais tarde Ransom e MacPhee estavam os dois de pé, sozinhos, na copa.
  ‘A moment later Ransom and MacPhee stood alone in the scullery.’

Such sequences of stills are used a lot in Steinbeck’s *Pearl* but often lost in Portuguese translation. Here is a typical passage. English bounded states then for a second she was black in the doorway and then she was gone are translated into Portuguese perfectives: she cut a black figure in the doorway for a second and left.

She paused for a moment beside the hanging box where Coyotito lay, then for a second she was black in the doorway, and then she was gone.

- **pt** 'Como uma sombra ela atravessou uma casa, parou um momento ao lado do caixote onde Coyotito dormia, recortou-se (pf), um segundo, negra, no quadrado da porta - e saiu (pf).’

Here are examples from Russian:152

- **ru** Ja vyshel, ne skazavshi bol’she ni slova, i chas spustja uzhe sidel v vagone.
  ‘I left without another word, and an hour later I was already sitting (ipf) in a carriage.

- **ru** Ja nabral nomer rabochego kabinetna Glumovoj i neskol’ko ostolbenel. S ekranra prijatno ulybal’sja mne Grisha Serosovin, po prozvishcu Vodolej, iz chetvertoj podgruppy moego otdela.
  ‘I dialled (pf) Glumova’s office number and was somewhat taken aback (pf). Grisha Serosovin, nicknamed Tattler, from the fourth subdivision of my department, was smiling (ipf) at me from the screen.

Ayano (1999) has examples from Japanese. Further languages are exemplified in Johanson (1998:§7.2.3). As Johanson concludes, everything works true to event type here. The imperfective does not denote the initial change, but denotes a point already or still within the next state. As for the impression of vividness, there is nothing that remains to explain here: vividness is, among other things, richness of observational detail, entailed by selection of particular points in time as points of reference for a running commentary.

**Discours**

An argumentative indexical present discourse can justify a point with a list of examples drawn from past events. The order of the events is immaterial, the main thing that they have happened and have bearing to the present. An example:

The publication in book form of the ephemeral triflings of a writer who prefers to conceal his identity, has drawn attention once more to a most regrettable state of affairs. The cheap gibes and vulgar music-hall jokes

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152Johanson (1998:§9.3) disallows vnezapno on stojal tam 'Suddenly, he was standing there'.
of this comedian have for long been a source of annoyance to all who have at heart the dignity of Letters. He has called in question, in a most downright manner, the genius of such men as Ibsen and Strindberg. He has assailed with the vilest abuse such unsayable names as Mr. Joad and Mr. Aldous Huxley. He has laughed loudly and rudely at Mr. Galsworthy and Sir James Barrie. Nothing, apparently, except his religion, is sacred to him. (McCoard 1978:55)

The first and the last sentences sum up the point of the list of perfects: they prove that nothing is sacred to the author being chastised, and it is a regrettable state of affairs.

A nice example of detective work (reconstructing the current relevance of past events from eyewitness reports and other clues they have left behind) is the following passage from Anne Tyler’s novel Celestial navigation. Amanda and Laura have returned to the house where they left their suitcases before going out, and can’t find them.

I said, “Mr. Somerset, did you put the suitcases in my mother’s room? “What’s that you say?” “Our suitcases. Did you put them somewhere?” “I never saw no suitcases.” “Well, someone did”, I said. [Amanda looks for the suitcases downstairs.] “Jeremy? I want to know where our suitcases are.” “Um, what suitcases are those, Amanda?” [Amanda goes looking upstairs and returns downstairs.] “Mr. Somerset,” I said, “think, now. Who else has come in while we were out?” “Why, nobody,” said Mr. Somerset. “The two ladies have been gone all day, and Howard left at seven this morning and never come back. I heard him go. [Mr. Somerset rambles on, complaining about Howard.] “Someone has stolen our suitcases,” I said to Laura. She was just settling Jeremy into a parlor chair, like an invalid. She looked up at me with her mind on something else and said “Oh no, Amanda, I’m sure they would never - “ “They’re gone, aren’t they? And no one’s been in that door but us and Mr. Somerset, he says he never saw them.” [Mr. Somerset confirms] “We’ve been robbed,” I said to Laura. “Oh, they’ll show up. I’m sure of it.” “No, they’re gone, I told her. “We’ve seen the last of them.”

Topic structure has been related to the interpretation of tense in many sources (Jespersen 1924, Inoue 1979, Leinonen 1966). Inoue (1979) defines the topic of a sentence as an entailment of the sentence, a definition consistent with the dialogue game definition of topic as a topical question (for answers entail the questions they answer, Carlson 1983).

Present perfect sentences, according to Inoue, address repeatable topics. Actually, the requirement that the topic is an extended now seems to give a better fit. Daniel Jones has done linguistic work in colonial India is acceptable addressing a topic like Which linguists have worked in colonial territories? although both Daniel Jones and colonial India are no longer there. Recall McCoard’s example

How has he been occupying himself this week?
Well, he has played golf on Tuesday. That’s all I know about so far.

Here too the topic is an extended present. Similarly Leinonen (1996) notes that the question Who has painted this picture? could be used in an art class where the students have just finished painting, i.e. the reference time is an extended now. The answer is likely to be in the simple past I painted it, for though the question is not specific about the time, the answer is. For the same reason, the perfect is used for existential questions about the entire past extending to the present. The simple past is proper and entails a specific or unique past situation is in question (Leinonen 1996).

Existence entailments of perfect


His sister has been an invalid all her life (she is still alive).
His sister was an invalid all her life (she is now dead).
Princeton has been visited by Einstein (Princeton is still there).
Einstein visited Princeton. (Einstein is dead).
Assyria/Britain (has) had many able rulers. (Britain exists).

Jespersen (1924:270) points out that it is the theme or dialogue subject (Carlson 1983), i.e. what the sentence is about, that is implied to persist (also Palmer 1987:§3.3.2).

Sentences containing words like yesterday or in 1879 require the simple [past], so also sentences about people who are dead, except when something is stated as the present effect of their doings, e.g. in Newton has explained the movements of the moon (the movements of the moon have been explained - namely by Newton).

On the other hand: Newton believed in an omnipotent God.

Here is a minimal pair where a focusing adverb makes all the difference by fixing the topic of the sentence.
Vlach’s (1993:267) example *Columbus has discovered America so you don’t have to* is about what you can do to America now.

Implications of present existence are entailments of the result state of the perfect, which it by definition denotes. Look at the result state in each case: the sister is an invalid, Princeton has a history with Einstein, the movements of the moon have an explanation. The result is a present tensed event type; whether its subject must exist depends on the event type (Musan 1997). McCawley (1971:107) adds the observation that a recent death can be reported using a present perfect *Dennis Brain has died in an auto accident* (so obviously the subject need not be alive). The result of *Dennis Brain has died* is *Dennis Brain is dead*, which surely does not entail that he is alive. In general, there are a lot of things that can be said of dead people in the present tense; my own mention of the late Jespersen above is a good example. (Cf. the section on space-time metaphor.)

Summing up, all that logically follows from all uses of the present perfect (well, the present perfect proves it itself), is that *one can talk about the dialogue subject (whatever the sentence is about) in the present tense*. The default dialogue subject of a sentence is the subject (Carlson 1983). Live people have their properties now and dead ones mainly had them in the past. Vlach (1993:268-9) puts the point as follows.

> It is a basic discourse principle that one’s contribution should be relevant. Sentences with perfect aspect, like other sentences, appear in the present tense when the temporal focus is present. In other words, they occur when what is being talked about is present rather than past. The principle that one should be relevant means that one should be relevant to what one is talking about and not something else. Thus on general principles of cooperative discourse, sentences in the present, including present perfects, are supposed to have current relevance.

The missing last step of the argument is that the past event *in* the perfect must be relevant to the present, as it is the informative part of the construction. The conclusion: current relevance is a rewording of the fact that the present perfect is a present tense (Carlson 1983, Sperber and Wilson 1998). That is all there is to it.

Intonational focusing affects implicatures (Crystal 1966, McCawley 1971:106, Bennett/Partee 1972). Crystal (1966:8fn) observes that stress influences preferences for a remote (existential) vs. near (hot news) perfect:

> I’ve been to the old Vic. (Where’ve you been?)
> I’ve been to the Old Vic. (Wanna go to the Old Vic?)

These implicatures can be derived from the dialogue game analysis of emphasis (Carlson 1983,1984). According to Carlson (1984), emphasis shows what part of a discourse move is *new* or *contrastive* relative to some premise, like the ones in the parentheses above. The intonation of the first sentence can be unmarked or place contrastive emphasis on the place. Hence it can be framed as an answer to a *where* question. If the emphasis is contrastive, the presupposition of the question is that there is a *unique* place where I have been. Because the reference time of the perfect is a near past, the unique visit must be the most recent visit. Otherwise the event would only be unique within a definite past reference time, and simple past would be used. Hence the recency.

The contrastive emphasis on *been* contrasts the verb phrase *have been* to alternative verb phrases that might make sense in the context but are false or otherwise less fitting than *have been: want to go, be going to, have not seen, do not know*. Many of such contrasts are contextually equivalent to *I have not been to the Old Vic*. This is unambiguously a universal negative (or negative existential) perfect, so its negation is an existential perfect. However, the dialogue game approach recommends caution with focus implicatures; they vary with context. In the following context, stress on *been* does not turn the perfect into an existential perfect:

> I am, I have been, and I will always be a sceptic.

Kilby (1984:27-28, cf. Matthews 1987:126fn) claims that the indefinite past or experiential reading of the perfect is linked to a stressed perfect auxiliary:

> I have opened it (= the window).

Emphasis on the auxiliary indicates contradiction or confirmation of an answer to a polarity question (Carlson 1983) *Have you opened it or not*? Obviously a sentence that goes with such a discourse structure cannot report hot news (the topic having been raised already).

**Discourse uses of temporal conjunctions**

Many temporal adverbs and conjunctions, including *as, before, since, still, when, while* have nontemporal, ‘logical’ or ‘discourse’ uses (explanatory, adversative, concessive). *After* is less prone for causal interpretation, apparently because it does not guarantee that the related events are immediately connected (Le Draoulec 1994:268). An obvious conjecture is that discourse uses surface where temporal interpretation fails by falsity or vacuity. Negative events exist only in
virtue of contrary expectations, so they are a good source of discourse uses (Le Draoulec 1994). Hamann (1987:66) notes that when gets causal meaning in ‘

When John had not arrived at six, we left.

An absence of change does not fix a particular time, it is at six that does. These facts combined invite nontemporal implicatures for the when clause (Declerck 1997:§3.1). When can come to imply (even) if or given that.

You see? This time John isn’t at home when we need him. (Declerck 1997:131)

Tout sa vie il a volé, quand il n'a pas tue. 'All his life he has stolen, when he has not killed.’

Leech (1971:45, Harkness 1987:103) notes that the (unusual) use of extended present helps construe the since clause an explanatory one in examples like

I am walking to work since my car broke down.

While becomes adversative and as explanatory when they relate events that are not synchronous. The difference in implicature is predictable: While implicates in a parallel course of events, and as implicates in the same course of events.

Bill was in Venezuela last year, while we are going there next year. (Heinämäki 1974:51).

Next moment they were out of sight, as the country heaved up betweenthem and him.

Still gets the concessive sense of nevertheless (Bybee et al 1994:65) with existential perfect (the temporal reading is inapplicable because existential perfect is irrevocable):

Even if you win the return match, I still have beaten you once.

The preferential sense of before in I’ll die before I give up is the only reasonable one given that dying is the last thing one does.

After reads non solum, sed etiam in examples like Le Draoulec's (1994:270):

Après qu'il n'eut pas rattrapé la balle qu'elle lui lançait, il fit encore beaucoup d'erreurs de jeu. 'After he did not catch the ball that she threw him, he made many more mistakes in the game.

Frames and scripts

Artificial intelligence approaches constructing or understanding a narrative as a process of event update or belief revision based on stored frames and scripts. Both boil down to boilerplate event types in my approach. They are loosely dual in that frames are static or object-like while scripts are dynamic or event-like.

In the simplest construal, a story begins with an initial state or frame called the setting. Change event types serve to update the setting by changing this or that component of the compound state into another state. What happens to the rest of the state meanwhile is maintained using default reasoning. If something is not entailed to change by the available scripts, it will stay put. Conversely, if something exceptionally does not change counter to an available script, then that facts bears to be mentioned. What is said and left unsaid thus depends on the script. Conversely, a narrative reveals its underlying script.

My point in this section is that this perspective on a narrative is built into the calculus of events without extra stipulation. The logic of causation and action built into the event calculus is nothing but default reasoning in one of its many guises.

The point of the AI approach is that nonmonotone (counterfactual or default) reasoning is applied in understanding. Suppositions are not only added but also removed in a way which requires a preference relation to be consulted to know what happens next. The idea is that the narrative script, or the background theory of the world, is a preferential theory, not just a classical one.

There is always a classical restatement, of course. A default logic can be translated into classical logic by making its parameters explicit. Just translate the default logic into a theory in classical logic, and do classical reasoning with that. But the nonclassical guise may be easier to work with, and it may model the way natural language works.

The idea is that at any point, a narrative establishes a new state of affairs. Every change in the story is an update, which may cause a belief revision. The simplest construction of the default idea is that everything stays put which is not specifically implied to change by an update. Examples:

I put ice in the freezer. I went out. I came back. I looked in the freezer. The ice was not there.

This is a surprising turn. Why?
• There could be a default rule to keep a state until the narrative forces to change it.
• There could be script (background theory) which entails that ice keeps in a freezer.

These solutions are different in complexity, but not in kind. The script of the second solution could involve a bit of common sense physics. Compare the story

I put ice in the drink. I went out. I came back. I looked in the glass. The ice was not there.

This is no surprise. Physically, the principle “things stay put unless you do something” is simply false. Things fall apart unless you do something.

Clearly, a naive application of default reasoning is not right for the explanation of narratives. But it may still be right relative to a set of background theories. It then means that those theories stay put unless the narrative says something to the contrary.

The model of a narrative is a game tree, which can be factored out into a number of strategies. These strategies define a lexicographic ordering of expectations about the world. It is a counterfactual model of the world far richer than the combined course(s) of events it entails or allows.

The dual representation of a course of events as a composition from strategies (or moves, which are small strategies) is related to the AI notion of problem solving as a search of a path in a net of condition-action rules. The solution space is a tree (or graph) generated as a free algebra under composition of condition-action rules (Nilsson 1980).

In sum, the view of change as update and narrative as belief revision is quite germane to the model of events developed here. It is just another perspective on events.
Mood

Mood is the grammaticalisation of modality. Modality can be formalised in algebraic modal logic as the image of a Boolean morphism of the algebra of events (see section on function algebra). The notions of image and modality are thus interchangeable: a modality is an image of a scene.

Image

The notion of image thus plays a major role in understanding modality. It has made a number of appearances before. The core notion here is that of morphism, a structure preserving mapping between domains. From this, we can determine that image is not an absolute notion, but a relation, a mapping between an original and the image. Given the relation is a mapping, the image can contain at most as much information as the original (when the mapping is one to one), usually less (when it is many to one).

An alternative way of construing the image relation is a three-way comparative relation, a pair of mappings between two domains and a common codomain. This way of relating image and original corresponds to my explication of the notion of metaphor (quod vide). It allows the picture to be partly true to the original, partly creative. The faithful part of the mapping is the shared structure or content between the image and the original. The creative part is what the image and the original do not have in common. This construal of the representation relation is symmetric between image and original. The composition of a mapping and an inverse mapping is a many-to-many relation. An organism bears an image of its environment, but also conversely.

Formally, an image, then, is the projection of a relation, literally the image of a representation relation composed by a morphism and an inverse morphism.

The left projection of the image relation I image is the domain x, the original, and the right projection image'1 the codomain y, the image. The functional notation y \subseteq x image'1 means the same as y be image of x, i.e. y is an image of x. Which also means any z including y has an image of x. An example of an image relation is cause: an effect is an image of a cause.

I shall represent the comparative image relation as the composition of two one-way image relations as x imagine y = x image z\image y, or x image\image y. The shared image z in the middle is the mode, role or content of the image relation. The ternary relation between image, coimage and content is commonly verbalised in natural language in ways which reflect this analysis. It makes sense to ask how one pictures something: as something, or in some role, where role is nothing but an equivalence class under some morphism. (This is just what grammatical roles are too.) The event type can be annotated as

\[ x \text{ imagine } y \text{ as } z = x \text{ imagine of } y \text{ that } z \]

The property of being an image is preserved under extensions. If x is an image of z, then any y including x is an image of z. (The converse may not hold, nor need y be a good image of z.) To have an image is to be the other end of the image relation, to be the image. When I imagine a scene, I form an image of it.\(^{153}\)

Any likeness or similarity can be represented in this way as a two-way image relation between two objects and a shared property. This analysis makes justice of the phrase x and y are alike in (that x and y) p where p the shared property. Another idiom for image relations is x hold/ take y for z where y is the source of the image and z the content.

There need not be anything particularly picturesque about an image relation. Any role or function is an equivalence class in a morphism. One who plays the rogue in a play or game is mapped to the role by the morphism defined by the cast of characters. Any game is an image. Life consists of games people play in their different roles as lovers, parents, employees, or friends by the rules of social norms. Norms in turn are constituted by game modalities.

Game tree

The feeling that time is not symmetric, that it flows from a deterministic past to a nondeterministic future, is common intellectual property. Future contingency became a problem of modal logic with Aristotle’s future contingency problem (De Int. 18b25-19b4), a theological problem about sin and divine omniscience in the middle ages, and continues as a philosophical problem of free will versus determinism today (Benthem 1985). These problems are related to the following model.

\(^{153}\) This does not extend to complete homomorphisms. A consistent first order theory is preserved under homomorphisms if and only if it is positive, i.e. contains no negations or implications. (Chang/Keisler 1971:126).
I consider the above diagram the Urbild of natural language mood and modality (van Benthem 1985:27). It represents a minimal model in which the modalities involved in planning and agency can be meaningfully defined so that their conceptual connections become clear. These are also modalities found in natural language expressions of the future. These modalities together constitute a framework of concepts for rational action, whose natural models are decision trees, or game trees, of the sort shown in the picture (Carlson 1994).


It seems an important old generalization about natural language modalities that mood concerns future: modalities which become grammatical moods start out from the branching future of possibilities. In a minimal system of tense, mood, and aspect, mood and future are one and the same thing.

In the temporal dimension of the tree, we can define tenses and aspects. The bottom line of the figure represents the course of events consisting of bearing right twice, \textit{right.right}, or equivalently, the sequence of states \textit{root.at R.atRR}. The two straight lines instantiate the event type \textit{straight}, or equivalently, \textit{right.right\cup left.left}.

In the modal dimension, we can define possibility as the presence of an event in some alternative course of events.\footnote{If there is only one future, possibility implies truth at some time and truth always implies necessity. Cf. Hintikka's Time and necessity in Aristotle.} Looking at what is possible at root, we can say \textit{may now.right, may now.left, may now.straight, may now \neg straight}, or equivalently, it is not necessary to go straight, \textit{\neg must now.straight}. It does not really matter what sort of possibility it is. Natural language modalities are essentially contextual: the basis of possibility and necessity varies with the context (Kratzer 1977, 1978, 1981). Hence it is no wonder that it is often impossible to tell in a given case just what modality is involved (Bybee et al. 1994:187). Possibility is possibility relative to some theory, consistency with some set of premises, and necessity is what follows from them. This idea is well known in modal logic (Hansson 1969): different modalities can be represented through one generic necessity operator relativised to different sets of premises. (Benthem 1985:17).

Call the generic modality \textit{root} modality in deference to linguistic tradition. What is possible and what is not determine the boundary conditions of the decision situation, the rules of the game being played. They can be redefined at will.

Three major varieties of possibility which get singled out in natural language grammars are dynamic, deontic, and epistemic possibility (von Wright 1968, Palmer 19??). Dynamic possibility involves what the player is able to do given his powers and skills. Deontic possibility concerns what someone (else) prefers (for one to do). Epistemic possibility is what is compatible with one's knowledge and beliefs.\footnote{Chung/Timberlake 1985 distinguish actuality, speaker involvement, subject involvement, and evidentiality, with the last one as a borderline case of mood/modality. The first three roughly map on epistemic, deontic, and agentive modalities.}

What an agent \textit{is able to bring about} are those things which \textit{he knows how to bring about: one has a plan}, a means for one to ensure the outcome (Moore 1981, Carlson 1994).

Goals, i.e. preferred outcomes or future courses of events, are the driving force of action, including both the agent’s own desires and obligations imposed by others. The agent’s preferences are marked on the diagram with bold lines.\footnote{More realistically, preferences are comparative, generating a conditional or counterfactual logic of preference (Carlson 1994). This is interesting because it reveals a deep connection between preference and the subjunctive mood.}
He wants to go straight, want straight, because that is true in all of the futures compatible with what he wants. Unfortunately, although what he wants is possible, he is not able to bring it about, and thus he cannot seriously intend to bring it about. If he knew at L or R where he was, he would be able to go straight.

Epistemic possibility is consistency with my knowledge of the situation. It concerns not only future but also present and past events, for I may not know, or may have forgotten, what happened before. Uncertainty also extends to other (players’) possibilities (plans, abilities), so it naturally scopes over the other modalities. We can assume that the player does not know at root what will happen, i.e. that all of the root possibilities are also epistemically possible for him. To make things more interesting, assume he cannot tell after making one turn which turn he made, i.e. that all he knows at L or R is that he may be at either, i.e. may at R and may at L are both true at both L and R. On the other hand, he knows that he did make one or the other turn, so must at R ∩ L is true too.¹⁵⁷

Since can is an existential claim, it is aspectually a state. In terms of modal logic, dynamic possibility falls logically between possibility and a necessity, because it has two simple modalities in a row: there is a strategy so that all future courses compatible with it make something true. He can bring about that he turns left or right now, and after the first turn, he can again turn left or right, but he cannot bring about (make sure) that he goes straight. That is a strategy he has not got, because he does not know how to follow it once he made the first turn. He may go straight at root in the root sense, but he is not able to do so in the dynamic sense, because he cannot control it. Whatever he plans to do, the plan may as well fail. He cannot intend to go straight, because he has no plan, no strategy, he does not know how or is powerless to bring it about (Moore 1981, Carlson 1994). To intend to do something is to have a plan: to have decided, chosen a particular strategy (whether or not that is what one wanted).

Can in the dynamic sense be able is the prime verb for dispositions (abilities, capabilities, tendencies, propensities). As often noted, it is vague between a dispositional state and its realisation. Languages with a perfective can resolve the vagueness with aspect: Il pouvait le faire ‘He could do it’ Il put le faire ‘He was able to do it (and did it)’. The aspect contrast carries over to necessity as well: Il devait/dut le faire ‘He must/bad to do it’ (it was necessary/it happened out of necessity). Similarly in Russian mog/smog and Bulgarian imperfect/aorist mozex/mozax. One difference in English between can and be able is that be able is more apt to denote a closed event than can: I was able to read it suggests more clearly that I actually read it than I could read it (though both can mean both).

The analysis of dynamic modality as an existential-universal type modality ‘it is possible (for me) to make it necessary (for others)” relates it to dispositions and counterfactual conditionals: there are certain conditions which if true, will necessitate something. A disposition supports a universal conditional, and when the condition holds, the consequent is realised. The Greek conditional/modal particle an is glossed ‘under given conditions’, hence also ‘possibly’ (Kühner 1896 §392.5.)

The dispositional sense of can prevails when the conditions are only possible, in the occurrent sense they actually hold and detach the consequent. If the condition holds continuously, the consequent does too. These cases are exemplified in I can (have the ability to) read, I am glad you could come (you came), I can see you (you are in my view).

These implicatures are consistent with the existential-universal quantifier character of able. By the possible worlds definition, possibility is the existence of conditions (a “possible world”) which make something true. This follows trivially in Boolean algebra – just choose e = a∩b.

\[ a \cap b > \emptyset = a \cap c > \emptyset \cap c \subseteq b \]

If the conditions c hold, the possible event b does too. Cans are constitutionally iffy (Austin 1961), and obtain a success sense when the ifs become true.

What one can’t stop one has to let go. The dual of can bring about is thus can’t help, let happen or enable whose quantifier character is universal-existential (van Bentheim 1991).¹⁵⁸

Control (Klaiman 1991, Givon 1975) means symmetric ability, Aristotle’s eadem potentia oppositiorum (Klaiman 1991:§3). Its dual is contingency: neither the event or its complement can be prevented. A contingent event just happens, uncontrollably or accidentally. I return to this in the section on control.

The game modalities generate an important dependence between possibility and preference. One can do things one wants, while one has to do things one does not want, because someone else wants it. This principle connects up with dynamics.

Strategic modalities

A tree of possibilities can be represented as a strategy distribution. This is analogous to a representation of a game tree as a union of choice functions for the various branch points. A strategy set corresponds to a sum \( \sum_\sigma \) of priority joins. The outcome of a play is a eet of such strategies. (Carlson 1994). For instance, the Urbild would correspond to the join ¹⁵⁷ In game theory, one would say that L and R form an information set for the player.
¹⁵⁸ Compare polite dismissal we have to let you go.
of the eight strategies available in the game. The last strategy, for instance, entails *I turn right, but if I turned left I would then turn right*. A utility function is formally another strategy. The solution of a game translates preferences over outcomes into priorities over strategies.

The tree of possibilities for turning left or right is described by the event type

\[(\text{left} \cup \text{right})^2\]

There is no particular indication of the *tree* structure in this formula: it is just an enumeration of four histories. It becomes a tree of possibilities when we merge consistent pasts in the histories so that there is only one state at the root. It is then impossible to say *which* history we are in at the root: future is nondeterministic.

A strategy “go always left” in this tree could be coded in many equivalent ways, for instance as

\[(1 \cap ? \leftarrow 1 \leftarrow 1 \leftarrow \text{left}) \cup (1 \rightarrow 1 \rightarrow 1 \rightarrow \text{right}) \cup 1\]

The image of a strategy as a way from status quo to a possible event matches the metaphoric of possibility. Where there is a will *there is a way*. Dually, what is necessary happens *necessarily*. What is not necessary is *avoidable*, there is a *way around* it. What can’t happen is *barred* from happening, there is *no way* for it to happen. To be able is to *know how*. Finnish *tietää* ‘know’ comes from *tie* ‘way’.

Conditionals

There is no end of studies of counterfactual) conditionals and their relation of causation (Sosa 1975, Dowty 1979:99ff, Nute 1984, van Benthem 1985, 1986). This is my construal of the results, philosophical qualms aside.

A starting point is that *all* conditionals in natural language are *contextual*, i.e. their logical form is really \(\sigma \rightarrow p \rightarrow q\) for some variable set of background assumptions \(\sigma\) whose choice depends on the hypothesis. One way to formalise the dependence is to regard \(\sigma\) as a strategy.

What \(\sigma\) may be varies freely. Conditional (dyadic) modalities are as variable and context dependent in content as absolute monadic ones. There is no need to build any particular necessity operator into natural language conditionals. What is said to follow from another thing is always understood against a set of context assumptions. Whenever one presents a conditional claim, it is up to him to specify, or to the audience to figure out, what assumptions the truth of the conditional is supposed to logically follow from (just as they have to do with any other sentence), and consequently, what the force of the conditional is. Logical necessity is one extreme case where the set of premises is empty; material conditional is the other extreme where the premise is the assertion of the consequent or the negation of the antecedent.

Counterfactual conditionals are contextual conditionals whose hypothesis is counterfactual, i.e. nonfactual or counter to fact (Goodman 1947, Sellars 1958, Mackie 1962). What one does in counterfactual thinking is *remove* the denial of the hypothesis from a set of premises (if necessary), *put* the hypothesis in, and see what would follow (the Ramsey test, Ramsey 1929, Goodman 1947, Rescher 1961,1964, Stalnaker 1968, Lewis 1973, Dowty 1979:100ff, Nute 1984, van Benthem 1985:23, 1991:217, 1996:34, Gärdenfors 1981, de Rijke 1994, Segerberg 1995). This is *monotone reasoning* (Gärdenfors 1981, Brewka 1992, Lascarides 1992). There is no fixed logic for removing an assumption from a set of assumptions and adding another. What will have to go and what is retained depends on one’s background theory; conversely, counterfactual reasoning - experimenting - is a way to study the background theory. The shifting of context explains why counterfactual conditionals fail those logical laws the classical conditional which reflect context independence, viz. strengthening the antecedent and transitivity (van Benthem 1985:20, 1986:94).

Following Lewis (1975b:12-13) one may separate the destructive (decreasing) step of a counterfactual argument from the constructive (increasing) step to obtain the logical form

\[\sigma \text{ Q} (p \text{ R q)}\]

where \(\sigma\) is a choice function that chooses from reference event \(w\) a subevent which does not include \(p\). \(Q\) and \(R\) are relations (generalised quantifiers) over event types. In the simplest case, \(Q\) and \(R\) are Boolean (material) conditionals. The overall quantifier character of a counterfactual conditional thus defined is existential-universal. It is the contextual dependence of \(\sigma\) on \(p\) that loses transitivity.

A choice function \(\sigma\) among situations or possible worlds \(w\) reveals an order relation among possible worlds. Different conditions on \(\sigma\) result in different logics. Basic conditional logic (Chellas 1975) can be modeled as a dyadic modal logic of preference relations (Hansson 1971, Spohn 1975, Lewis 1975b, van Benthem 1986). The alternatives that verify the consequent of a counterfactual conditional are those that are in some sense best given the premises, van
Benthem 1986:88). In the generalised quantifier framework, the subjunctive conditional is a *maximal* quantifier (it says the maximal A in some order satisfy B).\(^{159}\)

Dyadic modal logic is counterfactual in the sense that it does not just specify optimal choices in the actual or in an ideal situation, but defines, for any situation, the optimal choices in that situation. That is just the defining property of a game theoretical strategy (Carlson 1994). Binary order relations and choice functions are equivalent ways to define strategies. A third equivalent formalism is priority join.

Take the game tree of the section on modality again.

**Figure 18**

The entire tree \(t\) considered as a complex event token \(\text{root.right.R.right.RR} \cup \text{root.right.R.left.RL} \cup \text{root.left.L.right.LRU} \cup \text{root.left.L.left.LL}\) satisfies at \(L\) the (then) counterfactual \(\text{right} \leftrightarrow \text{R}\), or

- If I had turned right at root, I would be at \(R\).
- If I were at \(R\) I would have turned right at root.

In other words, the meet of event type \(\text{right} \leftrightarrow \text{R}\) with the singular event type \(t\) is nonempty. So is the meet of this event type with each individual course of events \(h\) of \(t\), but trivially so, by failure of an antecedent.

A counterfactual conditional fails only if its meet with a merely possible part of reality is empty. The subjunctive logic of counterfactuals is verified in the game tree as follows. Given my strategy of always going straight, i.e. the event type \(\text{left.left} \cup \text{right.right}\), if I turned left at root I would end up at LL; if I turned right I would end up at RR. Relative to the strategy, the closest worlds to are those reached by minimal or optimal changes from the status quo (keeping strategies in the game constant or optimising them relative to the change). For instance, if \(x\) chases \(y\) and \(y\) dodges by turning right, \(x\) can say \(\text{I would have caught you if I had turned right,}\) but \(y\) can counter \(\text{If you had turned right I would have turned left.}\) Both can be right: \(x\) is keeping \(y\)'s strategy constant, \(y\) is optimising.

A strategy, defined as a choice function, also specifies fall-back strategies when the optimal play is unreachable. In the above game, a player may prefer going straight to the right, but failing that, straight to the left. This strategy can be written as a priority join of the two strategies:

\[
\text{right.right} \cup \text{left.left} \cup 1
\]

or equivalently, as a priority meet of going straight and if possible, right:

\[
1 \cap (\text{right.right} \cup \text{left.left}) \cap \text{right.right}
\]

To find out what would happen if I turned first left, apply the strategy by substituting \(\text{left}<\) for \(1\), which gives the outcome \(\text{left.left}\). This gives concrete sense to the idea that counterfactual reasoning backs up to a situation where the hypothesis is still possible, and reapplies the rules by which the world is constituted given those premises.

**Logic of counterfactual conditionals**

Note that in my reconstruction of counterfactual conditionals, the context (strategy) \(\sigma\) alone need not entail \(e\). It suffices that \(\sigma\) together with \(e\) entails \(e\). This means that \(\sigma\) can include the actual situation \(w\). In terms of the idea that counterfactuals remove facts and add new hypothetical ones, the context \(\sigma\) only retracts facts. It need not contradict the actual situation \(w\), it just does not entail it. Grammatically, \(\sigma\) only accounts for the past tense or hypothetical mood. In topological terms, \(c\sigma w\) is a neighborhood of \(w\). Thus \(c\sigma w\) as a function of \(c\) and \(w\) can be viewed as a parameterised

\(^{159}\text{Maximal (relative to some order) is stronger than most or all in that it is not quantitative, i.e. not closed under permutations (automorphisms). Many different explications of the subjunctive seem to have this feature in common (van Benthem 1985:20-27), in particular Lewis 1973.}\)
modal operator ‘in the e-neighborhood(s) of w’. From the relational perspective, on the other hand, cause is a binary modal operator, or relation between event types which the choice σ function reveals (Hansson 1969).

This notation provides a bridge between unary and binary modal operators and conditionals (Kanger 1960). must e is explicaded as e cause e, which in turns equals cgw→e for an unexpressed counterfactual theory (strategy) σ, premise e and boundary conditions w.

Evidence that the choice of context is not fixed by the antecedent alone (Gabbay 1972, Nute 1984:410) are Goodman's (1947) or Quine's (1977) examples

If NYC were in Georgia, NYC would be in the south/Georgia would be in the north.
If Caesar had been in command in Korea, he would have used the atom bomb/catapults.

In such cases, we can negotiate the context for counterfactual conditionals so as to make them true or false as desired (Nute 1984:417).

The validity of contraposition is another old issue (Stalnaker 1968, Lewis 1973:§1.8, van Benthem 1986:§4). Some counterexamples to contraposition in the literature (Nute 1984:394) are not very convincing. Contraposition of a causal conditionals fails anyway because of asymmetry of time. Also, the contraposition of a counterfactual conditional is generally not counterfactual. This is why If you touched it it’d explode does not convert to If it didn’t explode you’d not touch it. If these flaws are removed by making both sides of the argument hypothetical, contraposition seems legitimate:

If your passport were valid in Russia, there would be a stamp on it. So if it had not got a stamp, it would not be valid in Russia.
If you invited men, they would not talk. So if you wanted talk, you’d invite women.

Here both conditionals are counterfactual and there is no temporal precedence involved, and the conditional does appear equivalent to its contraposition. The crux is that the supporting generalisations Russian legal documents are stamped and Women talk are not changed by the contraposition. Good counterexamples to contraposition consider different strategies σ in the claim and its contraposition. An example is Lewis' (1973:36) chauvinist version of the battle of sexes, where woman chases man and man avoids woman. The first clause is verified by Olga's strategy, the second by Boris'.

If Boris came to the party, Olga would come.
If Olga did not come to the party, Boris would come.

As Lewis (1973:31) notes, contraposition fails when strictness varies between different conditionals in the premises and conclusion. Contraposition holds when the context does not change, and then counterfactual conditional reduces to classical inclusion (van Benthem 1986:100).

**Counterfactuals in branching time**


Look again at the Urbild and consider different things I might say while playing the game. The bold lines show what I want to do at any choice point. At the root, I want that I shall go straight because if things go the way I want I shall go straight.

At the root If I turn left now I will get to L, obviously. But I can also say If I turned left now I would get to L; objective meaning is just the same. The conditional is not counterfactual yet, it is just hypothetical. Suppose I move one step straight ahead to R but have imperfect information about where I got. (L or R). At that point, I can say If I have turned left I will be at L. But I can also say If I had turned left I would be at L. This is a counterfactual sentence holding at R, referring to L. The conditional is just the same, the only difference is that I am at R and not L, i.e. that L is counterfactual. The difference is marked by counterfactual mood, which in English happens to look just the same as the finite past tense. Temporally, the consequent is simultaneous here with the true situation I am at R. This shows would does not mark future time here, but necessity of consequence. It even has a dual in might: If I had turned left I might end up at LR.160

Other variants make literal sense on the diagram as well. At root, I can say I have to turn right now or/otherwise/else/lest I would end up at L. Here the first disjunct is real, the second hypothetical. By the usual definition

---

160The past future implication of might have ended up is vague: the ending up is not temporally fixed relative to now.
of or as if not these are equivalent to If I turned left I would end up L, where the past morpheme is the mood. If the real disjunct is past, as expected two past morphemes appear in the conditional: at R I can say I turned right or I would be at L or If I had turned left I would be at L.

An interesting case, really a variant of the imperfective paradox, is I have to turn right before I would end up at L said at root. The before clause refers to L, which is not going to happen if I follow my plan. Indeed, the root is temporally before L, but it is counterfactual, hence the mood. To see the connection to the imperfective paradox, compare this. If I do end up at L by mistake, I can say I was turning (going to turn) right before I turned left. This is not a counterfactual sentence, for the progressive or past near future was future going to turn refers to my actual plan at the root situation. It can be described counterfactually too as I would have ended up at R before I turned left. Or even I would have ended up at R unless I had turned left.

The game semantics explicates the conflicting counterfactual implications of the imperfective paradox. He was crossing the street, the truck was going to hit him are true at the same time relative to different players’ strategies on the same game tree (the pedestrian’s and the truck’s).

Information grows in the branching time of a game tree by the metric specified by the strategies followed. The update of an information state with an event e is the nearest state in the metric where e holds. This relation corresponds in tense to until (Van Benthem 1991:§15.3). p until q says there is a future state where q holds, until which p holds. Correspondingly, a downdate is the nearest state back in time since e was determined. This means a counterfactual conditional can be formalised using since and until as

since (may <left) ((<right until left).left)

This represents the Ramsey test as a back and forth movement in a partial order of information states. The strategy is straight, and right if possible but we are at L. since backs up to the nearest earlier situation where right was possible. The plan was going right until the left turn was taken, but then plan B was to turn right. In English, since last I might have turned right, I was going right, until I went left, and then I was going left.

Summing up, counterfactual talk falls out from the picture assuming the past morpheme extends in meaning from a past tense to a conditional (hypothetical or counterfactual) mood, and that will similarly extends from a future tense to a consequent mood, order of knowledge replacing temporal order (Vet 1983). A past future is essentially counterfactual because the choice of alternative future depends on the choice of premises to retain and reject. It makes formal sense to consider the counterfactual step back in premises an inverse of the inferential step forward (Ryan/Schobbens 1997).

Langacker (1982) subsumes English past and subjunctive uses of the preterit under a distal operator which implies distance from the present (cf. Lyons 1977). Without a modal, this operator reduces to past tense, with a modal as in might, it enhances the contingency of the modal (might indicates a lower degree of likelihood than may). Is this right or wrong? I would like to say that it is true as far as it goes. It is also true to say that might is a counterfactual conditional, expressing what is possible given certain conditions which may or may not be true. But conditional possibility is a more distant possibility for a suitably defined tree distance measure.

Causation

Dispositions and counterfactual conditionals in turn are closely tied with the notion of causality and agency. When someone brings about something (makes necessary something that was only possible, and therefore eventually true), he is said to have caused that thing. c cause e entails that the cause is no later than the effect c≤e and that counterfactual conditionals hold which show c necessary and sufficient for e.

\[ c \text{ cause } e = (c\leq e) \cap (c<\text{cause } w \leq e) \cap (\neg c<\text{cause } w \cap \neg <e) \]

Consider this event type in the game tree of causation. We are actually in the bottom branch. Nature’s strategy is to exclude the branch marked in bold. That c is a sufficient condition for e means event type c cause e excludes the branch where c is followed by ¬e. That the cause is a necessary condition means c cause e includes the branch where e is preceded by ¬c. The latter condition makes cause antisymmetric -- which it is already anyway due to its temporal antisymmetry.\[161\]

\[ (\text{Temporal and causal asymmetries may be two sides of the same coin (Reichenbach 1955). Given the dependency between time and causation, time can in fact be reconstructed from causation, as has been maintained since Leibniz (Winnie 1977). In relativistic physics, both time and space are retrieved from causality (van Benthe}\]
Figure 19

Causation as just defined is reflexive:

\[ \text{e} = \text{e cause e} \]

any event by logic alone causes itself. For \( \text{e cause e} \) means

\[ (\text{e} \leq \text{e}) \cap (\text{e cause } \text{w} \leq \text{e}) \cap (\neg \text{e cause } \text{w} \cap \neg \text{e}) \]

which is logically entailed by \( \text{e} \). There is no temporal paradox, for \( \text{e} \leq \text{e} \) is a logical truth too. So in a trivial sense, everything happens by itself.

In other words, \( \text{e} \) is a first cause: a minimal element or atom in the algebra of causes and effects. A first cause is an event type which causes an event and is not caused by a third event (Reichenbach 1956:204). In a chain \( \text{e cause d cause e} \), \( \text{d} \) is not a first cause because it is not contingent in the causal tree of \( \text{e} \). It is not possible to control \( \text{d} \) (choose between \( \text{d} \) and \( \neg \text{d} \)) without controlling \( \text{c} \).

What we really mean by saying things happen by themselves is that they happen just by themselves: there is no other contingent event \( \text{c} \) so that \( \text{c cause e} \). Nothing in particular, or everything in general causes \( \text{e} \), or \( \text{1 cause e} \). This is another logical truth of cause the way it is defined here:

\[ \text{e} = \text{1 cause e} \]

In this case, the game tree for \( \text{e} \) reduces to the bottom half of the above tree, with \( \text{1} \) at the root \( \text{c} \). The mirror image identity holds of cause as well, given \( \text{e cause f} \) entails \( \text{e} \cap \neg \text{f} \) (it fails for counterfactual conditional):

\[ \text{e} = \text{e cause 1} \]

The denial of a counterfactual normally leaves the context intact. In habituals, there is a case for a dual (universal-existential) type of counterfactual \( \text{c cause w e} \leq \emptyset \) 'any context \( \sigma \) is consistent with \( \text{e} \).

Temporal and causal relations form an important locus of neutralisation and source of metonymical shift. The causal relation cause can, by the counterfactual analysis, be recognised as a specialisation of the temporal relation \( \leq \) under the counterfactual theory \( \sigma \). It picks out causally connected courses of events from the set of all courses of events. The logic of causal succession is a specialisation of the logic of temporal succession (witness for instance the constraints on transitivity). There is a morphism between the two relations obtained by setting \( \sigma \) to \( \text{1} \), which reduces cause to \( \leq \). This allows one to define a whole series of analogs between temporal and causal relations and connectives. This is what natural language does too. For example, passive ‘be caused’ _ cause p equals causal become p. Passive means ‘become Ved by something’, conversely become means ‘be caused by something’.

The counterfactual definition of causation entails a biconditional

\[ \text{c cause w} \leq \text{c} \leftrightarrow \text{must} \leq \text{e} \]

Note the difference to simple biconditional. A causal experiment must show that \( \text{c} \) is invariably followed by \( \text{e} \). But it does not have to show that the absence of \( \text{c} \) is invariably followed by absence of \( \text{e} \). It is enough for the absence of \( \text{c} \) to loses predictability. If \( \text{c} \) is not there, \( \text{e} \) may or may not appear, for random reasons. In other words \( \text{c} \) need not be the only cause of \( \text{e} \), just a necessary part of a sufficient condition. This improves on a traditional position questioned by Mackie (1965)

\[ \text{Asked what a cause is, we may be tempted to say that it is an event which precedes the event of which it is the cause, and is both necessary and sufficient for the latter’s occurrence; briefly, that a cause is a necessary and sufficient preceding condition.} \]

The necessary condition explains McCawley’s puzzles (1976). The roses died because the gardener did not water them is justified because as things are, flowers live if and only if someone waters them, and if anyone waters them it is the gardener. Cf. Miller and Johnson-Laird (1976:498), Frawley (1992:159).
To show that an event $d$ is not a cause of another $e$ one may show that $d$ is not sufficient, by means of a counterexample to $d \leq e$ or that $d$ is not necessary, by pointing out a more general cause $c \leq d \leq e$. Compare the temporal generalisation on the left below to the causal theories on the right.

| It does not rain until nightfall | rain causes nightfall | nightfall causes rain |

The first theory supports a counterfactual conditional if it did not rain night would not fall which is easily falsified by a dry evening. The second theory might not get falsified but replaced by a more general theory nightfall causes cooling and cooling causes rain which also explains rainy days.

What causes what is thus a question of the best explanation or best theory, what assumptions to choose as the conditional sentences, the invariants of the context, and which ones to take as the salient facts of a case, the antecedents that trigger a particular course of events. There can be many satisfactory explanations for the same event depending on these choices, many necessary and sufficient conditions relative to different choices of context assumptions. (Was the accident caused by the child running under the car or by the driver going too fast? Depends on what is the rule and what the exception, what is normal and what abnormal)\(^{162}\)

Then there is the asymmetry of causes and effects. By the definition of cause it goes back to the properties of counterfactual conditionals and time. Counterfactual conditional reduces to inclusion when the condition is possible (van Benthem 1986). Inclusion is a nonstrict partial order, i.e. reflexive, transitive and antisymmetric. The logic of counterfactuals is a classical modal logic relative to a fixed context, and satisfies the law of excluded middle in deterministic time. Deterministic time is linear and symmetric round the present, which means that one can turn it around, but not recycle it.

**Processes**

Processes have been described in temporal terms. Now we are in a position to consider their causal structure. Stability of processes involves the notion of feedback, or symmetric coupling of causes of effects. I hit you because you hit me and vice versa, and so it goes on until we are exhausted.

\[
x \text{hit } y \text{ (cause } y \text{ hit } x \text{ cause } x \text{ hit } y) *
\]

unfolds to

\[
(x \text{ swing cause } y \text{ hurt}) \text{ cause } ((y \text{ swing cause } x \text{ hurt}) \text{ cause } (x \text{ swing cause } y \text{ hurt})) *
\]

Many activities include feedback loops of this type.

<table>
<thead>
<tr>
<th>life (cause life)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>x hit y (cause y hit x cause x hit y)*</td>
</tr>
<tr>
<td>hungry (cause eat cause ¬hungry cause ¬eat cause hungry)*</td>
</tr>
<tr>
<td>sun (cause ¬rain cause ¬sun cause rain cause sun)*</td>
</tr>
</tbody>
</table>

Feedback does not conflict with the asymmetry of cause because the event tokens are different. The limiting case is a differential game equilibrium of simultaneous continuous variables which constitutes a dynamic state push/pull cause stay (Isaacs 1965).

Symmetric causation unfolds to multiple symmetries. $x \text{ r y cause } y \text{ r x cause } x \text{ r y}$ entails $x \text{ p cause } y \text{ q and } y \text{ p cause } x \text{ q}$ which is the same as $x \text{ and } y \text{ p cause } y \text{ and } x \text{ q}$. For instance, $x \text{ and } y \text{ hit 1} = x \text{ and } y \text{ hit } y \text{ and } x = x \text{ hit } y \text{ and } y \text{ hit } x = x \text{ and } y \text{ swing cause } y \text{ hurt and } y \text{ swing cause } x \text{ hurt} = x \text{ hit } y \text{ cause } y \text{ hit } x \text{ and } y \text{ hit } x \text{ cause } x \text{ hit } y$. The causation relation is symmetric, the players are in symmetric positions, everything is as symmetric as can be. There is a connection between factitive reflexive and reciprocal here: people who pick up a fight in effect hurt themselves. It is nicely captured by Genusienie’s (1987:209) example

So if a fist-fight started in the Slumberer’s classroom, the Slumberer allowed the two protagonists to beat themselves silly while he stood by and watched.

\(^{162}\) Dowty 1979 develops this topic in more detail on the basis of Lewis 1973. Cf. also McCawley 1976. Bennett (1988) compares the counterfactual analysis to the older analysis of cause as a necessary condition of a sufficient condition (NS) for an event:

There is a true $c$ such that $b \rightarrow c$ but not $b \rightarrow e$.

He notes that the NS analysis can be expressed in counterfactual terms. I believe the two analyses then amount to the same.
Counterfactuals thus form a connection between the notion of dynamic state (a state which is maintained by a process exerting energy) and possibility of change. Although there is no visible change, there is a (possibly visible) effort expended to maintain the state of no change. In other words, if the effort was not there, a change would happen. For instance, a helmsman must hold the rudder to prevent the ship from veering off course (perhaps move the rudder to keep the ship on a straight course). The analysis: hold cause ¬veer entails \( \sigma \subseteq (\text{hold} \rightarrow \text{must} \land \text{not} \land \text{veer}) \). In the given conditions, the ship might or might not change course if the captain does not turn the rudder), which entails the dual \( \sigma \cap (¬ \text{hold} \land \text{may} \land \text{veer}) \), i.e. if the captain did not hold the rudder, the ship might change course. If we hold the captain fully responsible for the course of the ship according to the \textit{eadem potentia} principle, we may want to say not only that he let the ship wander off course, but that his letting go of the rudder caused the ship to veer off course.

This again, using the existence-of-conditions definition of possibility, implies that the ship \textit{may} change course at any moment, i.e. a dynamic state involves a continuous potential for change. The branching future around a dynamic change is continuously deviating from the status quo, with the actual history as the continuous vector sum of such deviations and their corrections (equivalently, of the forces behind them). The causation relation is at once a true instance of a counterfactual conditional and the occurrent sense of \textit{be able} Conversely, \textit{be able} asserts there is (under the control of the agent) a condition \( c \) such that \( c \text{ cause } e \).

**Logic of causation**

Thomson (1977) studies the axiomatics of causality. Here are some putative axioms:

- Causality is irreflexive.
- Causality is asymmetric.
- Causality is transitive.
- Causality is contingent.
- Cause is no later than effect.

Thomson’s axioms describe a strict causal order, in which an event cannot be its own cause. In my analysis, cautious transitivity holds, i.e. cause is transitive when \textit{ceteris paribus} conditions \( w \) remain fixed. My definition makes cause antisymmetric so that causation is reflexive. Each event is also its own cause, or happens just by itself, i.e. \( p \text{ cause } p \) is valid. If \( p \) is a first cause, or accidental, it \textit{only} happens by itself.

Irreflexivity and antisymmetry seem to express the desideratum that a causal explanation is contingent and directed, i.e. cannot be logically true or circular.

Asymmetry of time implies that causality on event tokens is irreflexive, asymmetric and transitive. But reflexivity, symmetry and transitivity of causation for event types makes sense. It can describe an equilibrium or feedback loop which straightens out into an infinite sequence of causally related tokens like a finite automation into the set of its traces.

The idempotence of causes is significant for the theory of natural language diathesis. It gives a formal backing to the inverse relationship between causative and passive or reflexive (Genusien 1987).

\[ e = 1 \text{ cause } e = e \text{ cause } 1 = e \text{ cause } e \]

These principles bear comparison to the principles of relation algebra concerning the cancellability of relation algebraic identity and projection for absolute object types.

Thomson (1977) proposes further axioms relating events and their parts. They read like extensional versions of the contingency requirement. One of them says an event cannot cause or be caused by its parts. It would seem to rule out a causal analysis of

John wrote the book in a month by writing ten pages a day.

Another axiom goes: if an event causes another, it causes all its parts. It is not clear what count as parts of events. If John causes Bill to leave town it does not follow he causes him to leave town on horseback. Bill may have free choice or no choice as to the means.

An important connection was already observed between causation and conditionals. A causation event supports and is supported by a contextual (subjunctive) conditional which says that the presence of the cause on certain conditions \( \sigma \) entails that the effect follows (Lewis 1973).

\[ p \text{ cause } q \quad p \text{ cause } \text{`w \subseteq p≤q} \]

This characterisation of causation entails the \textit{propter hoc ergo post hoc} rule. This explication seems to fit both modal type counterfactual analyses of causation (Stalnaker (1968, Lewis 1973) and traditional Nagel/Mackie type analyses of cause as a necessary condition of a sufficient condition (Mackie 1965, Sosa 1975). All three analyses imply transitivity of causation if the \textit{ceteris paribus} conditions in \( w \) are kept constant throughout the chain.
Counterfactuals in the game tree establish a link between causation and the game theoretical explication of action (Carlson 1994). According to the latter, an agent brings about what follows from his particular choice of strategy together with given choices of strategies by the other players. What a player brings about (given what others are doing) is what is bound to happen if and only if he sticks to his plan. This explication fits perfectly the present explication of causation. The logics of counterfactuals, causation, and rational action are one and the same logic of contextual conditionals. No separate logics of causal and final explanation are called for.

**Algebra of causes and effects**

As defined, *cause* is a reflexive antisymmetric transitive relation of events, i.e. it induces a partial order among events, with “unmoved movers” or agents as minimal elements. When causes can be conjoined and disjoined and complemented, the network of causes of effects forms another Boolean algebra. The algebra of causes and effects then forms a quotient algebra of the algebra of events in the game tree. There is a Boolean morphism from the tree of possibilities and the tree of causes and effects. It follows then that all the temporal notions have analogues on the causal chain. The relation *cause* is the universal relation or unit of the causal chain, a quotient of the universal relation or unit become or change of the chain of events as well as of the universal relation or unit $\leq$ of the tree of branching time. This theme will be taken up again in the section on diathesis typology.

![Figure 20](image)

The game tree in the picture can be equivalently represented as the set of maximal histories in the tree (Carlson 1994). Each node in the tree represents an event token (state, situation), uniquely identified by the subset of histories it meets. Every set of histories is a tree. In fact any event type is identified by the tree it meets, so the Boolean algebra of event types is dual to an algebra of trees. In particular, the tree $\leq_e$ of an earlier event $e$ includes the tree $\leq_e$ of a later event $e$, i.e. $\leq_e$ is equivalent to $\leq_e \leq_e$. In the causation tree, $\leq_e$ holds in the right subtree but not in the entire tree. In other words, the event token $e$ follows $e$, but the event type $e$ does not. In the tree, $\leq_e$ (being equal to $\leq_e$ on trees) is a backwards linear partial order, i.e. reflexive, antisymmetric, transitive, and backwards linear:

$$e \leq e \text{ and } d \leq e \text{ entail } e \leq d \text{ or } d \leq e$$

Note that this definition loses the order of events when future does not branch. This is the sense in which a game is lost before it is over if defeat is certain. Here events are timed by not when they happen but by when they become necessary and can no longer be avoided. (Compare also scheduled future.)

The fact that $c$ is properly earlier than $e$ in the right subtree is shown by the fact that conversely the tree $\leq_e$ does not include the tree $\leq_e$, or equivalently, that the complement tree $\neg((\leq_e))$ does not include $\neg(\leq_e)$, or, again, that the tree of the complement $\neg\leq_e$ does not include the tree $\neg\leq_e$.

Note that this half of the proof cannot be carried out in terms of event tokens. In order for the inclusion to fail event $e$ must occur in two branches, so it cannot be a token after all. Causal explanation is always generic, about types of events as well as tokens. By saying *the cat caused this mess* I am relating an event token (this mess) to some event types about the cat and the mess related by a causal tree.

A strategy is a choice function in the algebra of trees which maps each tree to one of its subtrees. The entire tree of possibilities $I_1$ is characterised by the identity choice function $1$ which maps any tree to itself, excluding nothing. The tree $\leq_e = 1\{\leq_e\}$ of an event $e$ can be described as the choice by $1$ from the tree of $e$, or $(1\{\leq_e\})^*$.$\leq_1$. Since $1$ excludes nothing, this equals $(1\{\leq_e\})^*$.$\leq_1$.

The relation *cause* between causes and effects is defined by strategy *cause*. The causal tree of event type $e$ is what *cause* picks out of the tree $\leq_e$ of $e$, i.e. $\leq_e$ cause. That subtree (the lowermost branch in the picture) verifies $e \leq e$.

The event type $e$ cause $e$ thus entails that *in the causal tree, cause precedes effect*:

$$c \leq e \leq e$$

The converse does not hold. In the causal tree of $e$, the two branches ending in $e$, $e \leq e$ does not hold, for $\leq_e$ does not include $\leq_e$. This is the necessity side of causality:
Causation thus involves a strict order or proper inclusion. Analytically, one may separate sufficiency from necessity or contingency and treat the latter as an implicature.

It seems plausible that the causal algebra of event types is a quotient algebra of the algebra of all event types obtained when every event type is mapped to its causal tree. It is easy to ascertain that this mapping defines a Boolean morphism in the example tree, so that the causal tree of a Boolean combination of event types is the Boolean combination of the causal trees of those event types. What happens in the map that the algebra of events gets coarser. Causal order cause proves to be a homomorphic image of temporal order ≤. Event types which are temporally related may fail to be causally related.

Hume (1740) fails to find a difference between cause and ≤. Causality and succession do fall together when the counterfactual strategy σ is the identity strategy τ. When there is a difference, the tree of possibilities extends beyond σ to counterfactual situations. Hume’s point is that a counterfactual experiment is just a thought experiment. Any factual experiment tests ≤.

This logic of causation entails that counterfactual strategies σ satisfy choice function conditions that characterise weak order. This in turn means that causal consequence agrees with logical consequence from a causal theory and boundary conditions (van Benthem 1991).

Control
Causal chains form chains of control. Control in its simplest form is two-way causation:

\[
\text{c control } e = \text{c cause } e + \neg \text{c cause } \neg e
\]

This is depicted in the following symmetric game tree.

![Symmetric Game Tree]

Figure 21
The two-way choice can be generalised to other types of dependence between an independent controlling variable and a dependent controlled variable. The common notion is that the dependent variable depends on (is not a constant function of) the independent variable.

The basic actions (moves) e of an agent a of a game are supposed to be in his control, he is free to choose between them. They happen if and only if he wants so:

\[
a \text{ want } e \text{ control } e
\]

This means they are voluntary: the agent did them because he wanted to. The agent is responsible for them: he could have (indeed would have) avoided them had he wanted to.

Control is two-way ability. Its extreme cases are freedom, or full control, and determinism, or no control. Under full control, an agent causes everything he does and does everything he permits. Under no control, everything is determined, there is no choice. In either case, modalities degenerate away. The extreme cases are dual. No control for the agent is full control by Nature.

Free
Free is a weak contingency type modality: a is free if a may p and a may not p. Dictionary senses include ‘not under the control of another, independent, not under an obligation, not confined to rules, exempt, not exact, not fastened, able to move in any direction, clear of obstruction, without cost, generous, frank’.

Control is two-way ability, ability is an existential-universal notion. A player with a winning strategy is free in a strong sense for he controls the game. In a weaker sense, a player is free if others do not control him. That does not guarantee
that he controls his game himself. Active freedom to act, power or control, is existential-universal, passive freedom from coercion is universal-existential. In a deterministic game, one entails the other.

When the door is open you are loose, free to go, when door is closed you are safe, free from danger. Open and closed are topological notions, definable in two set quantifiers or three point quantifiers. Open is universal-existential and closed existential-universal. Compare also live and safe.

An object is fixed to another or depends on it when it cannot move freely, when it goes where the other one goes. Fixed entails being together, and staying together despite separating forces. A loose object is easily separated, it may move in any (well, at least in one) direction.

Mathematically, a free variable is surjective or epi (takes all values for another free variable), a dependent variable is injective or mono (takes different values for different values of a free variable). A set of generators of an algebra is free when any map from the set to another algebra can be extended to a morphism of algebras.

**May and must**

To prove that something is possible one shows how the possibility can be realised, by describing a situation where it is true, or constructing a path from the status quo into a situation where it is true. One shows that the possibility is consistent with what is necessary.

Intuitively, then, may e means e somehow, i.e. there is a (possibly counterfactual) condition c cause w on event types so that c cause w \( \cap \) e is nonempty. Remember that c cause w need not entail w because composition is defined by a priority meet. The dual of may, the necessity modal must is then explicated as c cause' w \( \subseteq \) e.

This approach makes a modal event type less indexical than an indicative one because of the contextual dependence or existential quantification over conditions in c\( \overline{e} \). This analysis of modality provides a close connection between unary and binary modal operators and conditionals (Lewis 1969).

The MSO representation of trees in terms of two successor functions suggests how modality falls under the regular expression regime. One successor function captures time as tree dominance. The second successor function orders paths of the tree by preference. Replace successor function with a set valued function, and we have relational modality. Replace it with a choice function, and we have dyadic modality.

The event calculus thus treats modal operators may and must as one-place operators on the algebra of event types in the manner of algebraic semantics of modal logic (McKinsey 1941, Jönsson/Tarski 1951, Hughes/Cresswell 1971), dual to possible worlds semantics (Thomason 1975, Bull/Segerberg 1983). This is not an exclusive choice; for a translation exists between the dual views.

Algebraic conditions on may and must correspond to conditions on the underlying choice function \( \sigma \) or the corresponding revealed binary relation, and reflect the logical laws characteristic of different modalities (van Benthem 1984b).

**Time and modality**

My treatment of modals copies my treatment of tenses in that state in the phase space of possibilities is made into an explicit local variable rather than a global implicit index.

Time is orthogonal to modality. This shows in the behavior of temporal adverbials with modals. A modal event type like the following may act as a state, since the possibility to enter holds at any moment of the opening hours:

You may come in from 9 to 5 / between 9 and 5

This can be considered a temporal case of what is known as free choice paradox.

Another observation is that counterfactual indicative modality is not quite natural language:

Although she is unmarried now, she may/can be married now.

This is not the way to express \( p \land \neg \neg p \) in natural language. Instead, one has to use a counterfactual modal

Although she is unmarried now, she might/could (have) be(en) married now.

The difference between the nonpast and past modal can be explained in terms of the tree of possibilities. The present modal denotes a potential (reals) forward strategy of form \( \sigma \) which is consistent with the facts of the index situation. This means that the possible event is not excluded at the index situation. The past modal denotes a counterfactual (irreals) backward strategy of form \( \overline{\sigma} \) which is able to remove the complement of the possible event from the

---

\(^{163}\) It is ok to say Although I think I am unmarried now, I may be married now. Not very well with know replacing think, because know is factive.
envisaged situation. In terms of the tree of possibilities, where possibilities decrease with time, the counterfactual strategy backs up until the possible event is undecided and then proves compatible with it.

Recall the dual definitions of priority join and meet which flip between decreasing versus increasing priorities. A forward strategy adds facts to a situation using priority meet. A backward strategy lets the boundary conditions in \( w \) fill in facts not specified in the strategy, or dually, read right to left, backward in time, it removes events from a situation using priority join.

Epistemically indistinguishable states can be collected into information sets. This produces a representation of epistemic modality on the tree. It is not difficult to see that identification of consistent pasts and pooling together of epistemically indistinguishable futures are interchangeable ways of looking at the world. Free will and ignorance about the future are dual. Free will and ignorance about the past (including bad memory) are doubly dual.

This is interesting from a tense logical point of view. In English, the modal present perfect may have done is exclusively epistemic. Why? The indicative mood tells we are dealing with a modally forward, temporally backward strategy here. This is only possible if histories branch backward in time from present time information sets, and that, in the Urbild model, means ignorance about past events.

Forward branching possibility also entails ignorance about the future, for we do not know what we and other agents will do. The difference is (we prefer to think) that here, there is nothing (or not everything) to know, ahead of time: our souls are exempt.

There is a well known connection between perfect and evidentiality, which can be brought into the picture here. Perfect, compared to simple past, is indefinite, i.e. an existential quantifier over past events. There can be a choice of past events at a given time only if possibilities branch in the past. Compare the section on evidentiality.

**Game modalities**

This section pulls together game modalities into a formalisation of a small game. The game may be the sequential game of *Left* and *Right* with imperfect information.

![Game tree](image)

**Figure 22**

Time and possibility are given in Nature’s strategy which chooses what may and must happen at any time. There is what *Left* wants to happen, or player *Left*’s preference formalised as a conditional want. There is what *Left* knows at each point: his information sets formalised as an epistemic modal. There is what *Left* can do, or player *Left*’s strategy set formalised as an ability modal. There is what *Left* plans or intends to do: her strategy choice formalised as a conditional intention.

Finally, there is what will happen: it is what Nature intends to do, a choice from the meet of players’ strategies. Like in Carlson 1994, with a different formalisation only.

**Game tree**

The game tree is described by the above automaton. Its formalisation as a regular event type is simply

\[
(\text{left} \cup \text{right})^2
\]

A *time* here is a type of simultaneous events. For instance, the root \( \text{I} \), \( \text{LUR} \), and the four endpoints put together \( \text{LLURURLLURRR} \) are times. At time \( t_0 \) or event type \( \text{I} \), I am at the entire set of histories, which is their join. At time \( t_1 \), I am either at \( \text{L} \) or \( \text{R} \), which dually are pairs of histories described by event types \( \text{left}< \) and \( \text{right}< \), respectively.
In language terms, this event type is just a set of four sequences of events. In what sense does it form a forward branching tree? We have to give the paths a tree topology. We know that

\[ 1 = 1^3 = 1.\left(\text{left}\cup\text{right}\right)^3 = 1.\left(\text{left.(left\cup right)} \cup \text{right.(left\cup right)}\right) = 1.\text{left.left} \cup 1.\text{left.left} \cup 1.\text{right.right} \cup 1.\text{right.right} \]

This expansion defines Nature’s strategy set. At root, Nature’s strategy τ can choose left or right. From both of these choices, there are two further choices, represented by the meet of the first choice by left and right, respectively. But note that the game event type is entirely symmetric:

\[ 1 = 1^3 = \left(\text{left\cup right}\right)^3.1 = \left(\text{left\cup right}.\text{left} \cup \text{left\cup right}.\text{right}\right).1 = \text{left.left.1 \cup left.left.1 \cup right.right.1 \cup right.right.1} \]

This is the situation of a player at the end of the game who does not know what happened: his information set is a backward branching tree which looks exactly like a mirror image of the tree of future. He might be told what happened in the opposite order: first what happened last, and then what happened first.

Come to think of it, there are more ways of describing the events: one might ask first who who won, and then what the players did. This too represents a choice function over plays of the game, in fact it describes the winning rule of the game. However, this choice function does not map homomorphically to time. Recall the extension of temporal order ≤ on trees by \( t \leq u \iff \sigma \leq \psi \). A choice function \( \sigma \) satisfies the monotonicity condition if

\[ t \leq u \text{ if and only if } \sigma \leq \psi \sigma \]

For instance \( 1\sigma = (\text{left}) \leq (\text{left}.\text{left}) = (\text{left})\sigma \). The winning rule \( \rho \) does not satisfy it. For instance, root 1 precedes left.left but the event type 1\rho = x^2 = left.\text{left.\text{right.right}} does not precede (left.\text{left}.)\rho = left.\text{left}.

Well, you say, there is a difference: the player at the end of the tree really is at one of the four endpoints, where the players at the root are not yet: at the beginning, they really is just one point. What does it mean to be at a point in the game? What are game situations?

To be at a point in a game is dually to be at (the crossroads of) a set of plays. Why can a move of the game only land us at one of those pairs of histories, and not the others, say the ones described by the event types left, right, L win or R win? Well, you say, because all that can happen at first, and has happened at time 1, is either left or right. The other two event types left and right will only happen later, they have not happened at time 1, they are not there yet, and winning is defined only on the length of an entire play.

The asymmetry of time simply comes down to the description that time 1 is considered as the join of situations left < U right<, not left < right, or L win \cup R win. What it comes down to is that left and right are atoms in this algebra of events, the alphabet of the language of reality. Basic actions or moves of a game are atoms. The game tree is an algebra generated by the moves.

Situations and plays are dual. All situations are joins of plays, but not conversely. A game becomes a decision problem just because goals, the sets of preferred plays, are not concrete situations: one has to choose how to realise them. The meet of the optimal plays for each player in Left and Right is empty: there is no one thing one can do to win. So is the meet of the optimal plays between the two players. A win is not an atomic situation, it is a join. The players have no actions L win or R win, the actions are left and right. (Conversely, in a game where winning is an action, the other player has no chance.)

Actions and situations are dual. Actions are transitions between situations. A situation s corresponds to the tree it sits on, which is a suffix closed set of plays. A suffix closed set of plays is dual to a prefix closed language.164 This duality is familiar from Nerode equivalence: a state of a finite automaton corresponds to the suffix closed language generated by it. The dual of a suffix closed language is a prefix closed language. Prefix closed languages correspond to safety properties. Suffix closed languages correspond to liveness properties. Safety properties are possible actions, liveness properties are impossible goals.

Intuitively, one has to get to a situation from the root by a continuous path of situations. This is related to getting to a situation: an object must be able to get to a situation by a continuous path. Continuity in order topology translates to prefix closure. A game situation is reached by a prefix closed or convex language of actions. That is why R win is not a situation but left.left is. There is a branch, a gap in R win that cannot be crossed once past. Conversely, a winning strategy defines a monotone path where every move is a winning move. Winning is a safe property, losing is a live one.

The situation corresponding to a tree of plays is its greatest lower bound, or last nonbranching situation. The situation of R win is 1, which is also the situation of the whole tree. A concrete situation is the full tree of its last situation. A prefix closed language is dual to a suffix closed tree, by duality.

164 A language is prefix closed if the prefix of any word in it belongs to it.
A situation must be consistent and concrete, or atomary, so that there is one path of actions which leads to it. The winning “situation” \( \text{R win} \) is not an atomary situation relative to the alphabet of \( \text{left} \) and \( \text{right} \).

Atomicity (concreteness) of a situation is relative to language. A game situation must be concrete in the alphabet of the game, but it can be abstract relative to some extension, say whether players wear hats. The point is that the game does not change when it is quotiented by that event type. A situation is concrete (not a join) relative to the quotient game.

**Modal event types**

That takes care of time. What about possibility? What type of event is \( \text{may} \langle \text{left} \rangle \) and how is it related to the event type \( \langle \text{left} \rangle \)?

Event type \( \langle \text{left} \rangle \) is the language \( \langle \text{left}.\text{left} \rangle \cup \langle \text{right}.\text{left} \rangle \). What does event type \( \text{may} \langle \text{left} \rangle \) denote? By earlier agreements it must denote 1, for \( \text{may} \) is a quantifier or truth definition on \( \langle \text{left} \rangle \) which says that the event type \( \langle \text{left} \rangle \) meets the game tree \( t \), i.e. equal to \( \langle \text{left}\cap t \rangle > \emptyset \) or \( ?\langle \text{left}\cap t \rangle \).

What time does \( \text{may} \langle \text{left} \rangle \) denote? \( \langle \text{left} \rangle \) denotes the length of a play. Does \( \text{may} \langle \text{left} \rangle \) denote the same length of time? It should, and it does, if time and modality are orthogonal. By the same token, \( \text{may} \langle \text{left}\cap \text{right}.\text{right} \rangle \cap t_0.t_1.t_2 = 1 \).

Treating time and modality as orthogonal leaves space for modals to show aspect.

On the other hand, \( \langle \text{left} \rangle \) is a state, and so is \( \text{may} \langle \text{left} \rangle \). Event type \( \langle \text{left} \rangle \) meets the root situation \( 1 = t_0 \), time \( t_1 \), and the event type \( \langle \text{left} \rangle \), and their joins \( u \). When it does, \( \text{may} \langle \text{left}\cap u \rangle \) denotes 1.

How does \( \text{may} \) relate to Nature’s choices? One would want to say that an event is possible if the rules of game allow it. The game tree is described by the strategy \( \gamma = 1 \cap ?(\langle \text{left}\rangle \cap ?(\langle \text{left}.\text{left} \rangle \cup \langle \text{left}.\text{right} \rangle)) \cup (\langle \text{right}\rangle \cap ?(\langle \text{right}.\text{left} \rangle \cup \langle \text{right}.\text{right} \rangle)) \)

which expresses the preference that the game proceeds by the rules. The modal event type \( \text{may} \langle \text{left} \rangle \) can be defined in terms of this strategy as

\[
\text{may} \langle \text{left}\cap w \rangle = (1 \cup ?w \cup \langle \text{left} \rangle) > \emptyset
\]

To sum up: a situation is a suffix closed set of histories, and a game tree is a join of choice functions. Among other things. There are alternative perspectives.

**Preferences**

In this section, I extend the choice function treatment to subjective modalities. In my analysis, a subjective modality is a map from situations to situations associated to a player, which means it is a choice function.

What is a player in this scheme? A player is not just a token time slice at any one situation, because the player must stay the same throughout time. Thus a player is a function from situations to tokens, like Hintikka’s individuating function or word line. Players branch off just like time and events do. I am at all of the histories first, then at one of two (and at two at once), then at one of four (and only at one).

What does it mean for a player to have subjective modalities like preferences and strategies? Nothing particular. To have preferences is to prefer things over others. To have a strategy is to be able to do things. Preferences and strategies are complex event types, but so are agents. Agents have event types by participating in them; dually, agents are constituted by the event types they participate in.

Preferences are event types which can be represented by priority expressions. Player Right’s preferences are expressed by \( \text{R want} = 1 \cap ? \text{R win} \), which is equivalent to

\[
1 \cap ?(\langle \text{left} \rangle \cap ?(\langle \text{left} \rangle \cup (\langle \text{right}\rangle \cap ?(\langle \text{right} \rangle \cap ?(\langle \text{right} \rangle \cup \langle \text{right} \rangle)))
\]

For instance event type \( \text{R want} \text{R win} \) is equivalently expressed with choice functions as

\[
1(\text{R want})^*w \subseteq \text{R win}
\]

Conditional preference, for instance R wants to choose right if Left did, is expressed by

\[
w:((\text{right} \cap ?(\text{R want})^*w) \subseteq \langle \text{right} \rangle
\]

The left side composition returns \( \text{right}.\text{right} \) which verifies the inclusion, so the event type denotes 1.
Information

In the section on function algebra, it was pointed out that knowledge as a $S4$ modality projects an image of of facts under a morphism, so what one knows is a quotient of what really happens. Information is related to causation by observing that the event type $e \text{ cause } e$ defines a morphism from cause to effect. The morphism is the dependence

$$c \text{ cause } w \subseteq c \leftrightarrow \text{ must } e$$

between the occurrence of $c$ and the necessity of $e$. Its contraposition is $\text{ may } c \leftrightarrow \text{ may } e$, saying $e$ may have been due to $c$, so the effect $e$ carries partial information about the cause $c$. Partial information is related to observability: $e$ is what is observable about $c$ at the time of $e$. For instance, the language (set of traces) of an automaton provides partial information on the internal states of the automaton, for a language corresponds to a class of equivalent automata. Whether the information carried by $e$ about $c$ is external or internal to $e$ is another duality, having to do with the observability of $e$ in turn.

The information available for player Right in the game of Left and Right folds the game tree into the following tree.

![Game Tree](image)

Figure 23

In this tree, the situations $L$ and $R$ are not distinguished, and consequently the choices $\text{ left }$ and $\text{ right }$ available for player Right at the information set $L \cup R$ do not distinguish winning plays from losing ones.

By Hintikka’s explication, knowing how is knowledge $de$ $re$. A subject knows those events and objects (note the direct object construction) which appear in the meet of the model sets epistemically admissible to her. Instead of a dichotomy between knowledge $de$ dicto and $de$ re, the morphism approach allows for a comparative notion. An event or object type is known the more intimately the more information is preserved in the epistemic image. In the above image, only the basic actions $\text{ left }$ and $\text{ right }$ remain atomic.\(^{165}\)

Strategies

Agency, by the explication given above, is an uncaused cause, or a cause which is caused by its own agency:

$$x \text{ do } p = x \text{ cause } x \text{ cause } p$$

Agent $can$ do things which they know how to bring about. By the arguments of the preceding section, a player’s strategy cannot depend on events she has no knowledge of. This is not a convention, but inherent to the logic of $can$ and $know$. To be able $means$ to know how.

By this argument, player Right has only two strategies in the game of imperfect information, corresponding to the actions $\text{<left}>$ and $\text{<right}>$. What she cannot act upon is the winning strategy that exactly matches her actions with her utilities:

$$1 \setminus? (\text{left}< \setminus? \text{<left>}) \cup(\text{right}< \setminus? \text{<.right>})$$

This strategy is excluded because it is not definable in the quotient game. Or equivalently, because its meet with the quotient game is the event type $\text{<left>\cup<right>}$ which does not tell her what to do.

The relation of ability $can$ to $do$ should be the same as the relation of $may$ to $will$. So what $can$ says is

$$(x \text{ cause } x \text{ cause } p \cap g) > \emptyset$$

which means that the event type $g$ of a game has a nonempty meet with the event type $x \text{ do } p$: there is a play of the game in which the action takes place.

Plans

A plan is an image of future action held by an agent. Formally, a plan is a strategy held by a player in a game. Interestingly, action is formally indistinguishable from causation. Causation is Nature’s plan, conversely, a plan

\(^{165}\)An alternative, probably equivalent approach is to allow for variable criteria of identity across epistemic alternatives (Hintikka 19??).
concerns what an agent is about to cause. Both causation and planning are future oriented: the plan precedes execution just as a cause precedes effect. A plan is an internal state of an agent which causes action (Tuomela 1977). A plan represents the future it causes. An agent causes something because he wants it. A plan for a hole causes the man to dig, the digging causes the hole to come about.

This is a duality too: plans are dual to action, just as possibility is dual to actuality. It is involved in the duality of causal and final meanings of temporal and causal connectives and in many dual flips between source and target cases. A goal foreseen by the agent pulls him to the future, while inanimate causes blindly push around events that follow them. But this is only a shift of perspective. What a player plans or intends to do is what he thinks he will do. The logic of belief is no different from that of knowledge except for the loss of reflexivity: what one believes need not be true. Want is similarly defined as a belief about preference (Carlson 1994) . This allows for agents to plan one thing and do another. Plans fail when one is mistaken about one’s abilities. Weakness of will happens when one is mistaken about one’s preferences. More on plans below.

Future

Quoting Lyons (1968:310), futurity is a notion that cuts across the distinction of mood and tense. Many languages are less systematic about the future than the present or past. The future is open, at least unknown, so there is less to say about it, and surely nothing to tell. Future is mingled with modality in a way past is not (Lyons 1977:677). Many languages make do with a two-way tense distinction, either past-nonpast, or, apparently less commonly (Ultan 1978), future-nonfuture: Hopi (Málotki 1983), Navajo (Smith 1991), Chamorro (Chung/Timberlake 1985), Yidiny (Dixon 1995).

It follows from unmarked tense and aspect that a nonpast closed event is future as long as now points at the moment of utterance; the event just has nowhere else to go. Conversely, in Hopi or Navajo, a nonfuture closed event is past by default.

Many languages have both near and remote futures. It is one of the universals of time reference that expressions of time tend to slip forward. Cf at once, gleich, tout de suite, seychas, English I’m coming, Portuguese já vou ‘I am already on my way’, French j’y suis, I’m there’, Finnish-Russian/Greek mentiin/poshli/ephuga ‘we’re/I’m gone.’ (Comrie 1985:20, Seiler 1952:67). By the law of procrastination, futures tend to start out as periphrastic near futures and end up as affixal remote futures.

Bybee et al. (1991, cf. Ultan 1978, Bybee et al 1994, Ch.7) surveyed 129 futures in 63 languages to find three major sources of future tenses and a fourth minor one:

1. Aspects
2. Motion verbs
3. Agent-oriented modalities
4. Adverbs

The aspectual futures in Bybee et al. exemplify familiar future uses of the imperfective and the perfective aspects. For change and motion, the present developments suggest the following classification of sources of future tenses.

become

come

near

may

Er wird wissen, On budet znat’

Va saber, hán tulee tietämään ‘He is going/comes to know’.

Está para comer ‘He is about to eat’

Can I go? It may rain.168

An event is nonfactual if it occurs in the scope of some nonreflexive modality, i.e. it is not entailed by the modality. Nonfactual by the definition, future possibilities are subject to hypothetical thinking, the goal directed modalities involved in planning, so various expressions of the future arise with such modalities. Future tenses get formed out of expressions of possibility, necessity, belief, volition, and intention.167 Conversely, future does duty for nontemporal modalities (Jespersen 1924:260ff).

166It is has been said that languages never have more future tenses than past tenses (Ultan 1978, Dixon 1995), counting only grammaticalised (affixal) tenses. At the same time, it is not uncommon for a language to have many lexically governed minor constructions for the future with different modal connotations. Tense is more likely to be grammaticalised than aspect or modality; of the tenses, future is least so (Dixon 1995).

167Bybee et al. (1994) argue that intention is the common denominator here: those agent-orientied modalities that imply intention develop into futures.

168Bybee et al. (1994:266) claim that epistemic possibility is not a common source of future. Not surprisingly, as knowledge and belief are not specifically about the future.
must Lat. ire habet > Fr. il ira ‘he shallis (bound) to/has to go
like He is likely/llyliable to win.
want Bulg. ste (< sta) Mod. Greek tha (< thelei na) will ‘want’
plan Greek mellei huein ‘It will (means to) rain.

These findings are aptly summed up by Ultan (1978:116): the one sense underlying all of these various categories of future marking is goal-directed activity - a game in short.

**Past future**

The use of *would* as the future of a past is morphologically fully compositional as the indicative past of an indicative future. A quick look at the past future *would* in corpora shows that it in a large majority of cases it is in the scope on some modality. In apparently extensional contexts it is synonymous with the past tense of the more obviously modal *be to* (be destined or meant to). A factual description of the same events would use an indicative past supported perhaps with subsequently.169

Colonial rule itself brought about changes that *would* (subsequently did) ultimately lead to its demise.

In women’s clothes, a neoclassic look based on a high-waisted “Grecian” dress that flowed simply from the bustline remained in fashion through the Napoleonic era until 1820. The simplicity and scantiness of this garb *would* not be seen (was not seen) again until the 1920s.

Johnston, however, was severely wounded, and command of what *would* soon be (was) known as the Army of Northern Virginia passed to Lee.

Expressions for counterfactual thinking recycle past future tenses. A sentence like *If he had money, he would buy books* can ambiguously describe a past disposition or a counterfactual situation. The reference to a hypothetical situation as it were replaces the reference to the past in these cases. Temporally, a counterfactual simple past future is nonpast where it contrasts with a past future perfect (see section on counterfactual typology).

The past future *would* is also found in past free indirect speech, a narrative in the scope of an implicit (someone) thought that. An interesting example of the contrast of we had to, we were going to have, and we would have to is the following translation problem from Ann Tyler’s short story Celestial navigation:

We were going to have to stay in Mother’s room because all the others were full of strangers.

The story is framed as a first person narrative by Amanda. Translating we were going to have to stay *stay>then<now* into Finnish with the equivalent of simple past we had to *stay>then<now* misses the past future reference and shifts the reference time of the story from the night before to the following day. On the other hand, the Finnish conditional, equivalent of the bound past future we would have to *stay<now2>then<now* is wrong too, because it only fits past (free) indirect speech, while the short story keeps the perspective of the speaker (it is discours, not histoire in Benveniste’s terms).

Joos (1967:124,187) claims *might* is never a real past tense of *may*. It can be a bound past tense, and appear in main clauses in free indirect speech:

He asked me if he might do so and I gave him permission. (Joos 1967:221)

**Future perfect**

A future perfect or *futurum exactum* can be formed compositionally using a nonpast tense of a perfect aspect which by previous definitions describes the result state of a nonpast event. As also follows from the definitions, it differs from a perfective future in that the event need not be properly future, it may have begun in the past. *He will soon empty the bottle* entails *He will soon have emptied the bottle* but not conversely: *now<~empty.empty* entails *now<~empty.empty* but not vice versa.

More than 70% of world oil is expected to be nationalized or government produced by 1985, and the concession system will *have* largely disappeared (be no longer there).

Bennett and Partee (1972) make the following predictions about the entailments of the future perfect:

<table>
<thead>
<tr>
<th>John ate the fish today</th>
<th>John will have eaten the fish by today</th>
<th>now&lt;~eat&gt;r&lt;~today</th>
</tr>
</thead>
<tbody>
<tr>
<td>eat&gt;then&lt;today&lt;now</td>
<td>does not entail (?)</td>
<td>John will have eaten the fish by tomorrow</td>
</tr>
<tr>
<td>John will eat the fish today</td>
<td>entails</td>
<td>John will have eaten the fish by today</td>
</tr>
</tbody>
</table>

169 This is a good example of a difference of *perspective*, explicated later on. The objective (global) perspective relates events to a common reference time, the subjective (local) perspective shifts (i.e. chains) reference times.
now<eat\in today entails John will have eaten the fish by tomorrow

John will eat the fish tomorrow does not entail John will have eaten the fish by today

now<eat\in tomorrow entails John will have eaten the fish by tomorrow

John will have eaten the fish by tomorrow entails (?) John will begin to eat the fish today or tomorrow

now<eat\r<tomorrow now<s\eat\(\{today\}\{tomorrow\)

Table 50

In my formalisation, by tomorrow is entailed by by today, and future perfect does not entail anything about beginning. This produces different predictions in the cases marked by question marks in the table.

A past tense can act as a future past in a future context. If a language has a choice between a simple past and a perfect, the perfect is used for a free futurum exactum, while a future simple past can occur bound to an interpolated attitude verb (Ikola 1949:51). In want of a perfect, a past tense will do for both purposes.

fi Kun palaat, olen jo lähtenyt (*lähdin jo). ‘When you return, I *(will have) already left.’
fi Kun palaat, huomaat etäi lähdin jo. ‘When you return, you will notice that I already left.’
hu Mire visszajössz, már elmentem. ‘When you return, I already left (pret).’
pt Quando chegares eu já saí. ‘When you return, I already left (pf).’

A fringe benefit of having tense and mood built into the same formalism is that it is possible to formalise exchange relationships between the two domains. A case in point is the use of future perfect to express (epistemic) necessity.

Those missiles will have cost a fortune to develop. <(cost<) = must cost

All this entails is that the missiles must be expensive. Future perfect does not place the development event on the time line. It does entail that the high cost is certain, for the strong future modal will asserts the perfect have cost is true at some point of every future, which entails that the event cost itself cannot fail to be true sometime.

Past future perfect

The past future perfect would have Ved is about the most complicated temporal construct that gets grammaticalised in natural languages. A point which should be obvious at least since Priorian (modal logic, global variable, local perspective) approaches of tense is that if each tense and aspect only relates its reference to the one it immediately applies to, nothing is entailed about the relation of the event time and the time of speaking: This follows from any compositional treatment of the construction, including mine. Referring to the discussion about consistent perspective, the point of origin in the past future perfect must be then, not now; now bears no definite temporal relation to conquer.170

No one knew then that after only a few years, the modest weaver would have conquered everybody’s heart.

then2<conquer<\then<now

The bound past future perfect He knew that he would have finished it three hours later finish<r> know\then<now is a composition of bound past future and perfect.

In contrast, a counterfactual past future perfect reads past (past (fut e)). For instance, He liked her. He would have liked to talk to her then like\then<then<now is the past of He likes her. He would like to talk to her now. like\then<now. The reference time of would have must be be at a double remove, at a branch point before the narrative then, as if the form went had would. Like the pluperfect does duty for the past of a simple past, the past future perfect here serves as the past of a counterfactual past future (Panitz 1998:36).

The mechanism of the switch can be diagrammed by the following parallelogram. The counterfactual situation where he talks to her (and likes it) can be reached by two moves back in time and one forward, or by one back, one forward, and another one back. Compare You should have gone there which is really the past of You should go there.

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170 This is a problem for some versions of a Reichenbachian multiple reference time approach to compound tenses (Lindstedt 1985:34ff). In other respects, my approach is not Priorian but closer to an explicit variable approach exemplified by Rescher and Urquhart.
Figure 24

Plans

Entertaining a plan is a dynamic state. *I plan to leave tomorrow/I am planning to leave tomorrow.* now \(\cap\) plan(leave) / now \(\cap\) prog plan(leave). The contrast between temporary and definite scheduled future *I leave/I am leaving tomorrow* seems based on this. One is a stable state, the other one is a dynamic one, possibly labile. Here is a Russian example:

Nastupil den’ o’t’ezda. Samolet *uhodil* vecherom, no on uzhe s utra nervnichal, byl sam ne svoj.’The day of departure arrived. The plane was leaving (pret ipf) in the evening, but he had been (pret ipf) on edge already since early morning, he was not his normal self.’

The future event is entailed by a plan or schedule. A schedule is an exterior plan, for instance, someone else’s plan, or a regular (habitual, iterated) plan. (My own regime or long term plan constrains my freedom in much the same way as someone else’s plan for me does.)

A scheduled future can be construed as a timeless assertion of fact about a timetable or schedule, a certain constellation of events. According to the timetable, the evening plane leaves in the evening, so today’s evening plane leaves tonight, consequently my plane is presumably leaving in the evening. This is not induction from a habit or disposition of airplanes (although it may imply such things), it is just the way things are set up, a property of the flight schedule, just as the evening plane is no particular plane. To verify it, one looks at the schedule or calls up the airline. Plans and scripts, like stories and plays, are place-time metaphors with their own internal time frame, so simple tenses can be used to ‘suit the action to the word, the word to the action’ (Joos 1967:111 citing Shakespeare). Plans can be temporary and they can be past, creating a type of past future (Smith 1978:48).

Something unusual is scheduled for tomorrow: Albert is playing tennis.

The plans for the following day were made: Albert was playing tennis

*Albert is playing tennis* can thus mean *It is being planned that Albert plays tennis*. Can it mean *It is planned that Albert is playing tennis*? Yes, if there is some event for the progressive to frame:

The plan is this: Albert is playing tennis with the countess while we take her jewelry.

A consideration which ties up the present tense of plans with branching future is this. In a model where future is uncertain, there is a live contrast between weak and strong future, *may* and *will*. *I may come tomorrow* is a weaker promise than *I will come tomorrow*. There is no such distinction within the futures allowed by the plan: modalities vanish in the same way they vanish for the established past. The normal form of a promise is *I will*, not *I do*\(^{171}\), because a promise is not a fact about a schedule, but an expression of will. The following examples show *now* does not have to cover the duration of the planned course of events, but just a time when the plan is set. (Said by an agent after setting the timing device on a time bomb.)

Now the bomb is going off at two. now \(\cap\) in plan(<off><2>)

Now the bomb is going off in two hours. now \(\cap\) in plan(<off in2h>)

Consider *The guest arrives tomorrow*. It can be analysed as *now \(\cap\) plan(<arrive><tomorrow>)*, where the first *now* is induced by *tomorrow* and the second one by the present tense. The plan is a state which holds at all points from now until the end of the plan. In particular, it is true now. So we can quite well consider the scheduled future a straightforward present.

Joos (1967:135) feels *I understand he has his orders to leave immediately, so he leaves by the first available transportation* is not quite English. Note that there is no future time adverb in the sentence. The progressive can be future without one: *We are having a picnic. Care to come?*

\(^{171}\)In marriage vows *I do* answers the question *do you want.*
Joos (1967:118) claims a state cannot have future reference without *will* or *be going to*. With ‘substantially any’ process verb one can say things like *Don’t worry: he leaves next week*, but *Don’t worry, the baby resembles his father next year* is not English.

Resemblances cannot be scheduled or planned. Acceptability does not depend on aspect but whether an event can be scheduled or not (Dowty 1977, Vetter 1972). One can say things like *The Orient Express is in Paris tomorrow* but would not normally say *The baby cries soon.* Smith (1978:54) notes that the present perfect cannot be interpreted as a scheduled future:

> They have arrived next Tuesday.
> They have eaten all the cookies tomorrow.

Perfecstes are not scheduled; they are not events in any ordinary sense. They never end, are never progressive and rarely generic. Compare also Dowty’s (1977) examples

> Lee was going to Radcliffe until she was accepted by Parsons.
> Rob was working (hard) on the research project until he got the job at the U of M.

*Go to Radcliffe* is ambiguous between achievement and activity senses, and it is the achievement sense that pairs up with a future progressive. *Work* is ambiguous between disposition and proces (*hard*). It is the disposition that seems future.

Scheduled future is infelicitous in Joos’ (1967) examples

> John lives in Oxford next year. (is living, is going to live)
> John did not sign up because he went to Oxford the following year. (*≠* was going)

The problem of the above examples seems to be rather that agents are not scheduled, they make plans. The following are quite acceptable.

> He asked when the ship arrived at Naples.
> He looked at the time table and found that the next train left in ten minutes.

Dowty (1977) proposes that the ‘restaurant past tense’ of *I had the cheeseburger with onions* is the simple past of a scheduled future *I have the cheeseburger with onions*. Simple past future can be expected to be rare because of the competition of a free past reading (Bache 1985:292):

> He found the gate padlocked on the inner side. It must have been forgotten that he arrived/was arriving that afternoon.

Palmer (1987:§4.4.3) cites an example of an iterated future progressive:

> He’s always taking them on holiday (but hasn’t yet).

**Trying**

Grammars describing the imperfective mention that it can take on a *conative* meaning (*imperfectum de conatu*), where it can be paraphrased with modal verb *try* or *threaten*. By contrast, the perfective can in these cases be paraphrased by *manage* or *succeed*.

> **ru** Ego posylali, no on ne poexal. ‘They tried to send (ipf) him, but he didn’t go (pf). (Lindstedt 1985:219)
> **ru** Levin slushal i pridumyval i ne mog pridumat’ chto skazat’. ‘Levin listened (ipf) and tried to think (ipf) what to say but couldn't (ipf) think (pf) of anything. ’ (Forsyth 1970:72)
> **gr** Epeithon autous, kai hous epeisa, toutous ekho:n epareouome:n. ‘I tried to persuade (ipf) them, and with those who I managed to persuade (pf) I marched on (ipf)’.  
> **gr** Diephtheiron prosiontes tous stratio:tas, kai hena ge lokhagon diephtheiran. ‘They attacked the soldiers and tried to kill (ipf) them, and managed to kill (pf) one officer.

Rather than say that the imperfective needs a (separate) conative sense, it suffices to say that *try* and the imperfective both denote situations where modal entailments arise. Trying to accomplish a result *is* being involved in an activity intended to lead to that result, which is what the imperfective of an agentive accomplishment denotes (Kühner 1896:§382.7).

English progressive is less apt to translate conative imperfective. Aspectually, a conative imperfective may denote an entire cycle of trying *pf prog e*, while English progressive is focally medial *prog! e*.

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172Poutsma (1921:80) has a list of attested cases.
There is a difference too: *try* is subjective. What one is doing while trying may be completely off the mark, one just *thinks* it might lead to the result. The imperfective is noncommittal about this, cf. *He was building/trying to build a house* (Dahl 1981:85). As expected by this account, the synonymy is at its best in agentive accomplishments. *He was arriving at the solution* does not entail *He was trying to arrive at the solution* nor vice versa. Another difference that *try* can distinguish between closed and open attempts, which the imperfective of course can’t. *(He kept trying/made a try)*. See also section on dynamics.

Lindstedt (1985:40) claims that Bulgarian requires the perfective with *uspeja/udade se* ‘manage/succeed’. Russian *uspet’/udat’sjia* are similar (Timberlake 1982:316, Smith 1991:332). This makes prima facie sense, for managing to try is just trying. However, iterative success is not excluded by this principle (cf. sections on Russian and Bulgarian). Conversely, verbs for trying and their complements can quite well appear perfectly, e.g. Russian *poprobujem vyjasnit’* ‘we shall make an attempt (pf) to clear up (pf)’

**Optative and subjunctive**

For a typology of mood, the following distinctions are useful: whether it is *strong* or *weak* (or a combination), whether it is *free* or *bound* (dependent), whether it is *past* (counterfactual) or *nonpast* (nonfactual), and what *type of modality* it can denote (epistemic, deontic, dynamic, any).

The Indo-European Ursprache is supposed to have had two dual nonindicative moods, a *subjunctive* and an *optative* (Krahe 1969: §43). The subjunctive was an expression for will and more generally conditional *necessity* (a strong modality), the optative one of wish and more generally conditional *possibility* (a weak modality).

Bybee et al. (1994:231) conclude that old indicative forms become subjunctive by getting pushed into modal contexts in subordinate clauses by newer main clause indicative forms (layering). The following changes are commonly found:

<table>
<thead>
<tr>
<th>from</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>present indicative</td>
<td>present subjunctive</td>
</tr>
<tr>
<td>past imperfective or future</td>
<td>conditional</td>
</tr>
<tr>
<td>future</td>
<td>present subjunctive</td>
</tr>
<tr>
<td>past anterior</td>
<td>past subjunctive</td>
</tr>
</tbody>
</table>

**Table 51**

Subjunctive as a *bound mood* is a variable mood which takes its descriptive content from sentential context. Chung and Timberlake (1985) consider the subjunctive the collective name to any grammaticalised modalities left over after the indicative and imperative are separated out. This may be a fair description for many languages (Palauan is mentioned as one). Bybee et al. (1994:214) find that dependent subjunctive moods have no characterisable inherent meaning. On the other hand, they suggest subjunctives develop from free modalities with iterated idempotent modalities (*It is necessary /permitted that he should/may go*) serving as loci of neutralisation.

I believe there is a meaningful core to a cross-linguistic category of subjunctive: subjunctive is grammaticalised preferential (deontic) modality. Prototypical subjunctive contexts are nonfactual, future, subjective, dependent, and involve counterfactual inference. Subjunctive has these features just because it depends on what *someone prefers* (wishes, fears). The comparative (dyadic) modal logic of preference and choice naturally generates counterfactual reasoning about alternative futures.

Subjunctive is closely related to the imperative. Both express what *you have* to do because someone (be it I, you, we, they, she or He) *wants* so The necessity here is an inference from goals to means: *si vis pacem para bellam*.

Is there a correlation between subjunctive in past temporal clauses and absence of a perfect/simple past distinction? I.e. does bound mood substitute for definite past tense? Latin and some of its descendants support this. From the other side, we have English, Finnish and classical Greek. Russian has neither.

**Perception**

Perception is a borderline case of a modality (Hintikka 1969,1975, Barwise/Perry 1983). *See something move* and *see that something moves* behave differently here; the transitive construction entails direct causal contact, the complement construction involves interpretation subject to error.
Perception, like its more abstract cousins knowledge and belief, revolve around the concept of image. The mathematical concept of image of a morphism seems to capture the gist of the notion. An object is an image of another if there is a morphism from the original to the image. The image is the sharper the more of the structure of the original is preserved in the image.

To perceive, then, is to receive an image of a scene through senses. The image is imprinted in the perceiver. All that this means is that some part or process of the perceiver (its mind, by definition) holds an image of the original under some morphism or other. In a weak sense, any effect which carries a mark knows its cause (Reichenbach 1956). On the other hand, a mark caused by one object may be a better likeness of another. When this happens, we have a false perception or belief. (This is something the ancients found hard to explain, because for them, an image of something entailed the existence of that something. But an image need not bear any causal relation to what it is similar to.)

Aspectually, a transitive perception verb like see is an acquisition of a simple state that is naturally bounded by what is seen (Vendler 1967, Mourelatos 1981:202, Smith 1991:82). This see has success grammar: what is seen is there. The subject of the success of see is a recipient, not a source. The closed aspect can denote the inception of the state or a cycle, while the open aspect denotes the state. Seeing a closed event is inherently a closed event, seeing an object or situation are acquisitions unless closed from the outside. I saw the tree fall is a cycle, I saw a tree/a problem are acquisitions. The progressive is excluded just as long as no progress is involved. Thus I was seeing them (spotting/meeting them) less often now and I am seeing (discerning) more and more of it are ok (Zucchi 1998:353). The reason is simple: see (resemble) more (often) are iterations or comparative changes (quod vide), not states.

A progressive see can also be agentive and noncommittal: I am seeing double/hearing voices can be my own doing, I am not receiving a double image from outside. Interestingly, I am knowing it cannot be given a similar reading. Know always has success grammar: one cannot know something and be wrong about it. This was part of what the Greeks meant by saying that knowledge was immutable: the object of knowledge is a truth, and what is true never becomes false. Compare I was remembering it was much bigger which also implies I was imagining things.

It has often been observed that English perception verbs like see, hear, feel use can in the success sense for progressive aspect (Palmer 1987:§4.6.2). The true gist of the observation is that can helps exclude an event reading of a perception (the one in veni, vidi, vici). This leaves over the acquisition readings (spotting and viewing). In fact, could see translates variously into Portuguese aspects depending on which reading of can is at issue.

Now they could see the little road ahead of them. ‘Agora viam (ipf) a estrada debaixo dos olhos.’ (state)
And then they could see the face of Coyotito ‘e então viu (pf) o rosto de Coyotito’ (inception)
…until the water cleared and he could see ‘por fim, a água tornou-se clara e pôde (pf) ver’ (inception)
and he raised the blade and looked at it and saw a line of blood on the steel. ‘Levantou a lâmina e viu (pf) no aço um delgado fio de sangue.’ (cycle)
He heard every little sound of the gathering night ‘Distinguia (ipf) o mínimo som da noite envolvent’
(iteration)

Conversely, via/via translate into English in several ways predictable from the aspect (Santos 1996:428ff). Some of the more interesting cases are

Marco Semprónio não o viu sair. ‘Marcus Sempronius did not see him leave.’ (cycle)
Da plataforma, ainda viu o sujeito voltar para trás, e com as malditas flores, perder-se no meio das pessoas
‘From the platform, he could still see the fellow turn around and disappear with the damned flowers into the crowd.’ (cycle)
Sentia-se descer lentamente, num poço sombrio e húmido, sem fundo. ‘She felt (ipf) herself slowly descending into a dark and humid bottomless pool.’

The first example is fully regular. In the last two examples, could see is justified by still. Felt is open because its complement is.

Aspectual properties of perception verbs reflect their diathesis. Perception verbs which have success grammar and act like states are subject causative: the subject is not an agent (source) but a recipient (goal) of the perception. Accordingly, there is no process for the subject to be in, while there may be one for the cause of perception. Conversely, when there is a sense activity, it can be a nonveridical one. If smell(f,F) says flowers f exude smell F and feel(i,F) says I sense smell F, then the differences are reflected in the following:

The flowers smell lovely. ‘The flowers have a lovely smell.’ (Whether or not anyone catches it.)
The flowers are smelling lovely. ‘The flowers are exuding a lovely smell.’
I (can) smell the flowers. ‘I catch the smell coming from’
I am smelling the flowers.  the flowers.'  progl pr f cause f I feel F
I am smelling flowers.  "I am trying/managing to catch the smell of the flowers.'
I feel F

Table 52
I return to the diathesis of perception verbs in the section on communication.

Evidentiality
In my explication, the definite past / indefinite perfect contrast is a distinction in temporal reference. Cross-linguistically, the distinction commonly carries contextual implicatures concerning the source of knowledge, which sometimes get grammaticalised into a variety of epistemic modality known as evidentiality (Comrie 1976:108. Johanson 1998:§8.7). My interest in this section is in the logic behind the trend.

The key observation here is that languages which have a evidential perfect allow definite past adverbiaI with it, i.e. they interpret definite past adverbials as unique but nonspecific; in fact, this is criterial for evidential perfect (Johanson 1998). Max on ilmeisesti lähtenyt eilen 'Max apparently left yesterday'. In English definiteness involves uniqueness, so English simple past is definite but not necessarily specific, while the perfect is indefinite but not evidential - and it disallows definite past adverbs. 173 Finnish definiteness involves specificity, hence Finnish simple past is definite and specific and the perfect indefinite and evidential. Lindstedt (1985:101) also finds it is more correct to call the Bulgarian perfective specific than definite.

Definite forms refer to identifiable events, indefinite forms do not. In nominal reference, identifiability involves uniqueness relative to some criteria of identity. I have suggested elsewhere (Carlson 1988) that in English (an article language) descriptive identity criteria apply to definiteness, whereas in Finnish (an article free language) acquaintance criteria are applied. Let me try to explicate this idea and its relation to evidentiality. In order to do so, I relate the grammatical notions of definiteness and specificity with the semantic notion of uniqueness within or across models.

From the point of view of possible worlds semantics, it is not difficult to see the connection between unspecificity and evidentiality. A definite event is one which is unique through time, a specific event is one which is unique through epistemic alternatives. Although I know exactly when I was born, I was even present at the occasion, I didn’t witness it because I don’t remember it. The event is not identical in the epistemic alternatives compatible with what I remember. (Carlson 1988) 174

Both definiteness and specificity thus involve an existential-universal quantifier prefix. A reference is extensionally unique (relative to a model) when there is an individual which is identical for all true substitution instances of a sentence. A reference is intensively unique (relative to a modality) when it has wide scope over the modality, which (by the possible worlds analysis of modality) means that the reference picks out one and the same individual in all relevant alternatives. Uniqueness means identity within a model, specificity means identity across models. Both definiteness and specificity are instances of the following schema, where = is an identity criterion, formally an equivalence or indifference relation.

\[ \forall x \forall y \ x \equiv y \]

Absolute uniqueness (exactly one x exists) is obtained by defining \( \equiv \) as extensional identity \( = \). Descriptive uniqueness is obtained by adding a descriptive condition to the definition. For instance, in the sun \( \equiv \) can be defined as the equivalence relation sun \( y \leftrightarrow x=y \). Contextual uniqueness is involved in I hurt my toe which does not imply I only have one toe, but that there is a certain toe I hurt. It is obtained by adding the assertion hurt to the contextual conditions, toe y A hurt y \( \leftrightarrow x=y \). Specificity as in I hurt a certain toe is obtained by defining \( \equiv \) as x=y at v \( \leftrightarrow x=y \) at w which says that x identifies one and the same individual in all epistemic alternatives v, w.

The Russell-Hintikka distinction between descriptive and acquaintance criteria (Hintikka 1975, Lewis 1984) is not absolute but a relative to modality. Given a modality, identity criteria which suffice for specific reference (uniqueness throughout the alternatives of that modality), are acquaintance criteria and criteria which do not are descriptive criteria. In perceptual contexts, more stringent acquaintance criteria apply than in epistemic contexts in general, and thus fewer designators are rigid (specific) there. For instance, that tree (accompanied by pointing) may be rigid relative to my field.

173 Definite past adverbials can occur in the scope of the English perfect when the occurrence is unspecified (in the scope of a modality or generic), see section on the English perfect.
174 I am not saying the Finnish simple past can only denote experienced events and the perfect inferred events. This is just one of the contrasts that can be made with the tense opposition.
of vision, but the nearest tree may not be. Point: the distinction between description and acquaintance is a relative one: it depends on the grain of the criteria used (Carlson 1988).

English uses descriptive identity criteria, meaning English definiteness is satisfied by uniqueness within an alternative, it does not entail specificity. Finnish uses acquaintance criteria, that is to say, in Finnish definiteness requires specificity, not uniqueness within an alternative.

Now the observation is that the English simple past uses descriptive, not acquaintance criteria, while Finnish uses its simple past for events which are known by acquaintance. The perfects differ respectively: the English perfect is excluded from reference to individual past events, while Finnish perfect with definite past adverbials assumes an evidential sense for past events not witnessed by the speaker.

fi Synnyin/olen syntynyt 1952.. 'I was born in 1952.'

English requires simple past.. Finnish also both perfect and simple past. The perfect is used in a resume, the simple past in an autobiography.

This contrast needs no separate rule. It can be derived as a markedness implicature from event types. Because English perfect is a near perfect, English only has one form for definite past reference. Hence it must cover all cases. Finnish, in contrast, has two past tenses for remote past events which differ in focus: the preterit denotes (is about) the past event, and the perfect the present.

A discourse about something is a discourse about identity: what that something is (Carlson 1983). By Gricean reasoning, if one uses a tense which avoids identifying the event in a discourse which is about that event, one does not either know or care which one it is (Carlson 1988). If the event time is definite, stronger identity criteria must be involved relative to which the event is not unique., i.e. specificity of some (other) sort is involved.

If this line of thought is right and evidentiality remains an implicature in Finnish, it ought to be defeasible. In fact, Lindstedt (1996) provides examples where Finnish definite past existential perfect is not evidential, but rather, conveys current relevance. (See section on Finnish tenses.)

In Russian too, evidentiality is one of the implicatures of the imperfective preterit (Leinonen 1982:201). Evidential perfect also occurs in German and in Scandinavian languages (McCoad 1978:256 citing Haugen, Lindstedt 1985:97). Lindstedt exemplifies it extensively in Bulgarian. Evidentiality is common specifically in the Baltic and the Balkan regions (Lindstedt 1996, Johanson 1998). It has been ascribed to Turkish influence during the Ottoman empire, as it is found in Albanian, Bulgarian, Macedonian, Georgian, but is widespread also in Uralic languages including Finnish, Estonian, Cheremiss, Votyak, Komi, Vogul, and Nenets (Cohen 1989:133). For Komi see Leinonen (forthcoming).

Inuktitut has separate affixes laug and miniq for experienced (conscious, perceived) and evidential (accidental, inferred) past events (Nowak 1994:301). The link between evidentiality and the present perfect in will be taken up again in the section on Bulgarian.

Joku on ilmeisesti ollut täällä eilen. ‘Somebody obviously was here (pres perf) yesterday.’
Mona Lisa on maalannut Leonardo da Vinci. ‘Mona Lisa was painted (pres perf) by Leonardo da Vinci.’
Kto otkryval okno? ‘Who opened (and closed) the window? (pret ipf)’
Kakto se vzda, mam sa ja znajali vsicki ‘As it seems, everyone knew (pres perf) mother’.

Another source of evidentials are the temporally indeterminate future past and past future tenses.

I have heard that he would have left for Australia. hear(leave<`then><now)<`now

A past future indicates that belief is conditional on the truth of the hearsay. Here would have amounts to a past evidential.

For example: Dickens uses dependent past in

I told her how I loved her … how I was always working with a courage such as none but lovers knew … how a crust well-earned was sweeter than a feast inherited.

because he is reporting what was said then, not what is true now. Fludernik (1993:179) points out that in English tense shift is suspended in a great number of cases. The following deictic tense indicates that the reported clause holds true now:

I learned this morning that they have begun / will begin work on the bridge.

Conversely, tense shift avoids responsibility for another's utterance, reports it noncommittally or with critical intent (Declerck 1991:186-7). This is not just an association – it is the logical difference between the above sentence and the next one. It explains the common occurrence of past future (conditional) and past perfect (irrealis) forms as reported or evidential modalities. (See section on evidentials).

I was told this morning that they had / would have begun / would begin work on the bridge.
A converse case in point is the use of future past to express (epistemic) necessity.

Those missiles will have cost a fortune to develop. \(<\text{cost}<\) = must cost

All this entails is that the missiles must be expensive. Future perfect does not place the development event on the timeline. It does entail that the high cost is certain, for the strong future modal will asserts the perfect have cost is true at some point of every future, which entails that the event cost itself cannot fail to be true sometime.

The two etymological sources of evidentials relates to the division of evidentials into inferential and quotative subspecies depending on the source of evidence (inference from present effects or second hand from an informant). Evidentiality is is implied by indirect discourse. Obviously, hearsay is a case of knowledge by description. Indirect discourse in turn links evidentiality to (epistemic) modality and (conditional) mood. In the dialogue games of Carlson (1983), different sources of knowledge are brought to the same baseline by considering Nature an additional player of a dialogue. In dialogue game terms, knowledge by acquaintance is construed as facts told by Nature directly, through senses or otherwise, while other sources of knowledge are moves by other players. Hearsay comes from others while inferences are drawn by the player himself. There is a difference in reliability: Nature does not lie, while inference and hearsay, including things our senses may tell us, is fallible.\(^{175}\)

DeLancey (1997) proposes mirativity or surprise as a further species of evidential meaning. The connection is not hard to see. Evidentiality contrasts knowledge from indirect sources (inference, hearsay) to direct knowledge (acquaintance). Mirativity contrasts two sources of knowledge. The conflict forces one to reconsider either source as fallible. The contrast I did not see Kemal come but Kemal seems to have come applies equally to evidential and mirative meaning.

DeLancey notes cross-linguistic tendencies connecting person and aspect with evidential/mirative interpretation. Evidential meaning goes with first person and perfective while mirative goes with second person and imperfective. This can be examined from a game theoretical point of view. First and second person are the persons for the main players of a game, observing one another’s moves as the game proceeds. Normally, a player is master of his own moves (can choose and will remember them), but cannot control and may have imperfect information about other players’ moves. A forgetful player who has imperfect information about his own moves is game-theoretically equivalent to a team of players with limited communication. The present perfect describes the present observed situation, the past imperfective the past inferred one. Cf Lindstedt (1985:265) (also Comrie 1976:108-110, Dahl 1985:153):

Inferentiality is resultativity the other way round: in resultativity, a present state derives from a past event; in inferentiality, a past event is inferred from the present state of affairs.

Maker’s knowledge goes with intentionality and agency. A player is an intentional agent when he is in control of his moves; when he is not, he is passive and subject to the moves of other players. This connects evidentiality and mirativity with passive diathesis (DeLancey 1997).

The connection between direct object constructions and knowledge of acquaintance (Hintikka 19??, Dahlstrom 1991:70), can also be explicated with object causation. Knowledge by acquaintance is knowledge acquired by direct contact with the object of knowledge. Evidentiality is not just associated with causation here, causation is literally what evidence is about. (See section on knowledge.)

**Permanent and temporary states**

Many languages make a distinction between permanent states (qualities) and temporary states (conditions). What is the relation between this distinction and the open/closed distinction? There is one, but not a strict entailment. There is a generic quantifier in between. A condition is not temporary in all individual instances, but on the type level: a condition is typically a cycle. Hän on nuorena/vanhana ‘(s)he is temporarily young/old’ is odd either way, because age grows monotonically; neither youth nor old age can be a cycle.

The condition that a temporary state denotes a cycle, i.e. a bounded region in time, matches well the etymology of iberic temporary auxiliary estar ‘stand, be somewhere’ meaning being within a region. For unlocated states, the main difference between temporary and permanent auxiliary is that the temporary auxiliary entails an initial boundary, the unmarked one does not.

A sentence like Illness is temporary is a generic truth, not an exceptionless one. Although many (most?) illnesses follow their course, have a beginning, a middle, and an end, all illnesses don’t: some begin and never get better, some are inborn and last for life, some just go away with time. Some ailments are obvious by just looking at someone, some are recognised by a characteristic course. The categorisation of illness as temporary only shows that this generalisation (illness varies rather than does not vary with time) seems more fitting. One way of putting it is that a condition is a state

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\(^{175}\)Note that evidentiality words like appear, seem, obvious, evident are all perception words.

\(^{176}\)Dixon (1995) quotes Tuyuca (Barnes 1984) as a language with a five-term grammaticized evidentiality system distinguishing vision, other perception, inference from perception, inference from generic knowledge, and hearsay. It is more usual just to distinguish direct acquaintance from indirect sources.
that can change any time. But it can also continue, so it is aspectually a state (i.e. open event type). It has a typical temporal profile, but not a necessary one.

What is the relation of the permanent-temporary state distinction to the simple/progressive aspect distinction? Here, there is an obvious connection. The auxiliary of the Portuguese progressive is estar, not ser. Ser has no progressive estar a ser doente, estar doente is used. The distinction partly coincides with the simple/progressive distinction in English, but is not identical to it. I described the English progressive as picking out a process involved in an event. Portuguese estar does not imply a process, it just implies a temporary state, the generic possibility of a change. Portuguese allows the progressive with temporary states estou a ver/comprender. I see, understand’ but not with permanent states estou a ter comprido/Portuguesa ‘I am having understood/being Portuguese’. The paraphrase for the Portuguese progressive is not in the process of, but temporarily (for the moment). The phrase esta doente ‘is ill for the moment’ means ‘is ill at least for a bounded time’, not ‘ill only for a bounded time’. It does not entail - at most suggests by implication - that the illness ends. The event is not necessarily bounded by its complement, but perhaps only limited by some observation event. (Compare the use of the perfective with temporally limited events.)

The progressive can be regarded as the grammatical aspect corresponding to the Aktionsart of dynamic or temporary state, where a a dynamic state is a state maintained by a process and a temporary state is a state typically bounded by its opposites. Both have similar implicatures of provisionality and/or change associated to them. Ritchie (1979:97) matches the progressive and simple tenses of the dynamic state live with states and events as follows:

When he lived in London, the rents were high. live\high
When he was living in London, someone bombed the GPO tower. live/<bomb>

This comes as no surprise, considering the lifetimes of the matched events.

Russian uses long vs. short forms to distinguish between permanent and temporary states: Ivan bolt'nolj ‘Ivan is indisposed/a sick man’. Finnish has an essive case livo on sairaana/sairas ‘livo is (temporarily) ill’. Of people of sound constitution, the normal collocations are Hän on sairaana/terve ‘(s)he is temporarily ill/healthy’.

Compare I am seeing double to I am seeing you. The observation is that a veridical (factual) modality does not allow the progressive. Propositional attitudes that are vague about implying truth take the progressive only when they don’t: I am remembering to take the keys, I am seeing that you are ill are odd. The Greeks stressed that knowledge is immutable: knowledge cannot change to ignorance because what is once true cannot become false. Knowledge has ‘success grammar’ (Ryle), This suggests that know is a lexical perfect of find out (etymologically it is).

The contrast between permanent and temporary states also figures in generic vs. existential sentences (Milsark 1977, Löbner 1990) Firemen are intelligent/available, Kinder sind faul/spielen draussen.

Adjectives exhibit aspect (Lakoff 1966, Bolinger 1967, Dowty 1972, Bartning 1980, Riegel 1985, Borillo 1998). There are permanent states round, dumb (s’s’s)’, temporary states sick, hot (~s’s~s), and result states full, clean (~s’s). Resultativity (half-closure) is relevant to German or Dutch result adjectives Es muss los/gross ‘it must (get) big/away’, De flies moet leeg/groot. ‘the bottle must (become) empty/(be) *big’. Recall also that temporary states sound better in existential present perfect than permanent ones: Napoleon has been ill/dead (Klein 1994:101, Mittwoch 1988:210).

We might approach formalising a temporary state with as an optional cycle ¬sick? sick. For instance be ill would then denote a state of illness optionally (and preferentially) surrounded by better health. The phrase preferentially suggests a representation in terms of priorities as

(∅*U? ¬sick).sick.(∅*U? ¬sick)

which equals, given sick is a state,

(sickU? ¬sick).sick.(sickU? ¬sick)

This suggests in turn a representation in terms of priority iteration sick*? ‘sick as briefly as possible’. A healthy life is the event type

( ¬sick? sick)∗?

that is, live as long as possible and be sick as little as possible. Note that healthy, the complement of sick, is a permanent state. This may generalise.

Posture is a dynamic temporary state when potential is lost, a static permanent one when no work is done, as in I am lying here / My ancestors lie buried here.

Future and prediction

In this section, I use the logical tools just regained to analyse the connection between future and prediction exemplified in the two senses of will. Will is etymologically an expression of will, i.e. preference or intention. Intention is specifically future preference and choice. In the game semantics of action (Carlson 1994), there is no particular
metaphor involved in using will as a future: what will actually happen is the intersection of the strategies of all of the players, including Nature. What will happen is the outcome of everyone’s individual wills.

Smith (1978:49) refuses to treat will as a future tense because of its modal predictive use in The store will have your book by now or The documents will have arrived last week. Joos (1967) suggests will does not denote the future, its meaning is ‘adequate assurance at the time’. Given branching future, one does not have to choose. Branching future is a modality. The schematic meaning of will is a strong future modality. In its different uses, the base of the necessity may vary. Natural language modals are vague about the exact range of possibilities covered. The same holds for the rest of natural language modals, which is one reason why opinions about logical principles governing them are so shifty. The predictive will can be approximated by a more complex modal prefix ‘it will turn out that p’. The event itself may be over, but the prediction is that it will turn out to hold, if an inquiry is made. He will be at home by now can thus be represented as NFMFKp ‘in all events there is a possibility to know that p’. If all the modalities involved are epistemic, the whole prefix reduces to just kp ‘it is certain that p’.

Theories of mood

Bybee (1994:177) distinguish epistemic, agent-oriented, speaker-oriented, and subordinating modalities. Agent-oriented modalities are the game-oriented modalities above, speaker-oriented modalities are sentence moods177 and subordinating modalities include the subjunctive. This grouping is geared toward gramaticalisation: while agent-oriented modalities are rarely inflectional, the other three often are. This suggests that agent-oriented modalities get grammaticized to the other three types.

Lapolla/Foley (1997) refine mood into modality, status, and illocutionary force. Modality covers root and deontic modality, status covers epistemic modality and (ir)realis, and illocutionary force covers imperative. Operator scope cross-linguistically is generalised to be

force < evidential < tense < status < negation < modality < direction < negation < aspect.

Besides being syntactically (and semantically) distributed on nested levels of sentence structure, these operators are also represented in Lapolla/Foley as an orthogonal linear projection. There is a morphological motivation to this in that operators are commonly coded as morphological affixes on verbs or auxiliaries in this order.

A more piecemeal approach to the operator scope universal is to code operators as close to surface as logic permits, making use of conversions and commutative relations between them. A partial ordering might fall out from grammar and pairwise commutativity constraints between operators.

For instance, in Finnish negation is an auxiliary and modals are main verbs or adverbs. English deontic must not come and epistemic may have come go to ei saa tulla translate into ‘is not allowed to come’ and on voinut tulla ‘has been able to come’. Epistemic may not have come is translated on voinut olla tulematta ‘has been able to be without coming’ or ei ehkä ole tulut ‘has perhaps not come’.

Expressions of ability and possibility develop from positive words expressing existence, possession, knowledge, power, strength, freedom and success. Expressions of necessity come from predominantly negative words expressing lack, excess, force, compulsion, bound, or confinement: one wants (lacks) something, owes something, or is forced or bound to do something. There is an exchange between the two poles in competitive vs. cooperative games: if what is bad to me is good to others, it may eventually be good for me as well. Ideally (when a game has a solution), what one can and wants to do, may and must do, are in equilibrium. Such an ideal situation is a locus of neutralisation between different modalities.178

Diathesis

Diathesis (disposition) is the Greek term for voice. It refers to the ways language relates objects and events, in more contemporary terms, argument structure. Voice, more specifically, is diathesis grammaticalised on the verb (Genusien 1987:53). Not that I care too much how one adjudicates between received terms. Terminology is like taxonomy: helpful at the start of an investigation, but ancillary once a calculus starts to emerge.

It was noted earlier that aspect types are only a temporal projection of the whole spatiotemporal and logical structure of situation types. In this section I consider how this projection arises from diathesis (argument structure, Melchuck 1993).

A grander plan than this is winking in the event horizon here: a calculus which directly accommodates natural language, all in one, with no sortal separation between the contributions of lexis, morphology and grammar, or between levels of syntax, semantics, and pragmatics.

177 Sentence mood is grammaticalised performative use of modalities, e.g. imperative and interrogative (Carlson 1976).
178 Bybee (Bybee et al. 1994:192) argues can has moved from meaning know how ‘mental enabling conditions exist in the agent’ to meaning root possibility by losing first the animacy feature ‘mental’ and then the internal feature ‘in the agent’.
My formal approach to diathesis is based on enriching the event calculus with combinators to regroup and rename event sequences. The resulting combinatorics allows direct representation of many alternative expressions of argument structure.

The abstraction of argument structure from event sequence happens with operators which include abstract verbs like _be_, _become_, _change_, _go_ and _cause_. But the syntax of these operators will be polymorphic. For instance, in _become_ e, _become_ is a prefix operator short for ¬ e.e. In x _become_ p it is an infix operator short for _become_ x _be_ p. Similarly from e to f will turn out to be a rewriting of e ≺ f, and x _change_ from p to q one of x p ≺ x q.

**Diathesis types**

Natural language vocabularies are not endless in structural variety. There are recurrent argument structures which correlate with aspect types. Without attempting an exhaustive description, I want to single out a few types.

Concept analysis is a familiar philosophical exercise since Aristotle, but it has linguistic interest too. I had better say at once what I want to do with argument structure analysis here. I use compositional analysis as a tool for understanding natural language talk about events. I don’t presume (i) that it is the only way to analyse words; (ii) that the same sort of analysis can or must be carried out for the whole vocabulary, or that (iii) every lexical entry should have a fixed unique exhaustive correct analysis in compositional (or any other) terms. But I do find it illuminating. So here goes.

For notation, I shall use the event calculus, making use of the possibility that an event name may contain whitespace. Parentheses are used to indicate groupings when there is doubt. For ease of reading and writing, I will occasionally replace Booleans with their English names _not_, _and_, or _or_.

*Null-place event types* like _rain_, _windy_, _cold_, _dark_ are the simplest. Their logic is propositional logic, or Boolean algebra. They can be _located_ spatiotemporally by inclusion in other spatiotemporal regions: rain[] today, rain[]here. (This is the way we have dealing with all event types so far.) Other types of quantifier-free algebras can be defined on event types (Keenan and Faltz 1985), as we have done here (concatenation defines a semigroup). Concatenation allows building new null-place event types like windy.rain<cold. ‘it is windy just before rain, later it gets cold’. Spatial regions can be structured using geometry and qualitative dimensions using order relations (Dowty 1979:127).

A peculiarity, though no novelty (nil novum sub sole) of my argument structure representation is that it is all based on the same calculus. There is no sortal distinction between events and objects here, it is the same stuff all through. Events as well as their arguments are brought together with the operations of meet, join, and concatenation. This is not as curious as it first may feel: objects are events if Quine is right. The difference between _rain_ and _water_ is not that big after all, it is all in the way of speaking.

The thought of individuals as relative atoms takes getting used to, like Quine’s idea of water as one huge sprawled individual. Consider for instance _IBM is in Paris_. Is this true or not? It is true that IBM has a base in Paris. But all of IBM is not in Paris. The event type _IBM is in Paris_ is not two valued, but an element of a more general Boolean algebra, denoting the meet of IBM and Paris. A meet is two valued when subject and predicate are relative atoms, either identical or disjoint.

This way of shaping argument structure has typological advantages. It helps gloss over categorial differences between languages. Verbs and nouns are not clearly distinct categories in some languages, nor are verbs and prepositions in others. For instance, Chinese is hard to gloss in English because glosses could go either way. This is another case of categorial polymorphism, in the spirit of van Benthem (1986).

**Subject**

*One-place* predicates are not much different, nor is their logic any more complicated than that of the location events (it also reduces to Boolean algebra): john[]here, john[]boy.

The complement of _john here_ is ¬(john here) which amounts to ¬john|¬here: either no John, or not here. Given _john_, ¬(john here) is equivalent to john ¬here but denotes different. Consider what ¬(john) here should mean. What ¬john denotes depends on the algebra the complement is taken from. Say it is _here_. Then ¬(john) here denotes _here|john_, or _here \ john _ which is the type of others but John here. The complement of _john here_ says nothing about that. More likely, it is _john_. Then ¬(john) here denotes _john|john here_, or _∅ here_, which is _∅_. This construal makes ¬(john) here equivalent to ¬(john here), which seems apt.

Copula _be_ in _John be here_ may denote the unit element of everything in this semantics. Being as Aristotle (and Hintikka) would have it: existence _be|x equals_ x as does identity _x be_ x. and predicate _xx_. Even _not be_ could be construed as a denoting expression, the complement of _be_. Under this construal, _not be_ maps event types to 2.

For a discussion of a Quinean flat ontology, cf. Bartsch (1995). The flat structures here can be decorated with compatible stratified types in the style of Bentham (1987), Keenan/Faltz (19??) or Cresswell (19??).
The circumstance of John be animal being an individual predication translates to the observation that John and animal are relative atoms. Genericity makes nonatomic assertions atomic, for instance the earth is blue shifts from part true to true.

Montague grammar and the theory of generalised quantifiers rehabilitated Aristotelian subject predicate grammar for logicians and linguists. It is no longer an obstacle to getting quantifier semantics right (Barwise/Cooper 1981, Westerståhl 1989).

The mission of subject-predicate structure is to single out a subevent out of an event as the subject of discussion. be is like a lambda abstraction operator which forms a predicate be here, whose inverse is application john be here. In the first place, such abstraction is needed for sustained conversation, to express sharing between events which have common parts.

Bona fide (countable spatiotemporally continuous) objects are individuated differently from (other) events. Among the ground rules are that an object has a definite place at all or most times, and that all of the same object cannot be in two places at the same time. Like states, objects are all there at any time. This shows that aspectually, individuals are thought of as steady state functions from time to space. They trace a trajectory in time while events just lie there.\footnote{Even individuals may be sprawled around, like pollution or Microsoft Corp.}

Predication topicalises the subject argument by abstracting over it: \( \text{john}(x:x \text{here}) \) treats john as subject (what something is said of) and here as predicate (what is said of it). Aristotle Cat: makes the subject-predicate distinction by saying that properties are said of individual objects, they are not in them like their parts. This drives in a difference between class membership and inclusion. The distinctions arising with individuation between particular and general, token and type, mass and count, amount and number, bring in set theory, quantification theory, and lambda calculus. Argument abstraction allows different perspectives on the same predication: around x equals y:x in y, y be with x equals x have y.

More generally, one-place predicates can be rewritten in various ways using abstraction to introduce higher-order two-place predicates or one-place functors be, in, at. This is syntactic sugar and does not change the logic as long as the higher order arguments are not quantified over: \( \text{john be here, john be at school} \).\footnote{The partitive is a from case still used in a few spatial adverbials. The essive and translative are location and goal cases for predicate complements and certain spatial and temporal adverbials. Etymologically, the from cases contain the partitive and the at/in cases the essive. The genitive shows traces of a to case.} Booleans can be construed as (generalised) quantifiers, every man be animal for inclusion, some man be animal for overlap, while their logic remains the same (van Benthem 1982:57). The complexity of quantification theory only comes in with nested quantifiers on two-place event types.

The argument structures that interest me here are those obtained by combining the event calculus with one-place predicates. It seems to me that they allow representing a significant portion of the basic event types.

**Location**

It is well known that temporal relations get expressed with spatial ones. Although the choice of form is often more or less transparent and consistent with a basic topological meaning, it is not predictable (there are many alternatives which make sense). English has at eight in the morning on Sunday in April in 1997. Finnish has kahdeksalla aamuilla sunnuntaina maaliskuussa vuonna 1997 ‘from eight on morning during Sunday in April during 1997’.

Finnish is a particularly clean exponent of a locative case system. The full system of locative cases opposes directional (from-to) cases to location (at) cases and multiplies this distinction with a trichotomy between internal (in), external (on/at) and neutral (of/during/for) cases. The locative subsystem (internal cases out of-in-into vs. external cases from-at-to) is quite regular both semantically and morphologically. The neutral (grammatical or temporal) cases are related to it by etymology and by various grammatical analogies.\footnote{The internal-external distinction has a wide sphere of application in Finnish. External cases express possession and distinguish distal from proximal deixis.}

In vector algebra, directions can be defined in terms of ordered pairs of points. See section on direction below.

**External and internal cases**

In this section, I discuss the contrast between external and internal cases.\footnote{There have been a number of points at which this distinction has already made a brief appearance. In a primitive form, the distinction appears as the Boolean minimal four-element lattice where an element is either within (included in) another element, outside it (included in its complement) meets it (has a common part), or joins it as another part of a shared whole.} There have been a number of points at which this distinction has already made a brief appearance. In a primitive form, the distinction appears as the Boolean minimal four-element lattice where an element is either within (included in) another element, outside it (included in its complement) meets it (has a common part), or joins it as another part of a shared whole. In topological spaces, these distinctions can be detailed further. A region may belong to the interior of another region, to one of its neighborhoods, share a boundary with another region, or two regions may be separate but share a...
As can be expected, relations between points (closed regions of zero diameter) are external relations: a point is at (in a neighborhood of) another point. In the limit, as the neighborhood gets smaller, at becomes the relation of coincidence.

Using these relationships, we can define external and internal cases in terms of one another: around is the dual of in. External cases at, on, by and with are specialisations of near, defined by in around. My technical usage of at as \{\} is one specialisation (the meet of in and around., in fact). Another is adjacency next to, the limit or superlative of near.

In Finnish, the dividing line between internal and external relations seems to be whether one object enters the boundary of another object (not just its neighborhood). Internal cases are of course used when one object is properly within another one. But they are also used if one is stuck in the other: when there is more than a loose surface contact. Thus we have naula on lattialla/lattiaassa, kenkä on jalassa/jalka on kengässä ‘the nail is on/in the floor, the shoe is in the foot/the foot is in the shoe. Ruoka/vieras on pöydällä/pöydässä ‘the food/guest is on the table/at the table’.

Locative cases are commonly used to form tenses and aspects. Locative (at/in/on) cases of infinitivals are a favored way of forming progressives. The English progressive the times are a-changing comes from on changing. Many languages, for instance Finnish and Chamorro (Chung/Timberlake 1985, cf. Traugott 1978) also use directional cases for progressive forms.

Orientation
The semantics of spatial prepositions introduces further considerations from geometry and common sense physics (Pustejoff 1977), including dimensionality, orientation, metrics, and dynamics. It is best to proceed slowly here. A lot of prepositions are already definable in terms of the distinctions we have got. Multiplicity is due to metonymy and metaphor as products, quotients and (other) morphisms are taken between semantic spaces.

Orientation involves dimensions and directions. Time and space provide two dimensions and one direction. before and after are already defined by the asymmetric order \(\prec\) of time. front and back are asymmetric perspectives on spatial between, which is definable as \(x \prec y \prec z\). (From the perspective of \(x\), \(y\) is in front of \(z\).) Directions toward (or ahead) and away (or back) can be defined as \(\text{near} \prec \text{near}\) and its converse. In the section on paths, we consider how along, across, by, and past can be construed from these ingredients. In general, equivalences here go many ways, so that it hardly pays to look for a fixed hierarchy of definitions.

aside can only be characterised negatively as yet (near, disjoint, not before or after). For positive orientation in space, more dimensions are needed to allow for left, right, up and down and related prepositions (over, under, above, below).

left and right can work in a local frame of reference, so that their behavior is characterised by group identities of unit vector addition

\[
\text{left}.\text{right} = \text{ahead} \quad \text{left}^2 = \text{back} \quad \text{left}^3 = \text{right} \quad \text{left}^4 = \text{ahead}
\]

up and down work the same as left and right relative to a local frame, e.g. a plane making loops. Relative to a global frame of reference, the rules are different. Given a vector base and a metric, geometry is well on the way.

Mappings
Prepositions (meaning for, toward, along, through) are apt to describe mappings. Fattening frogs for snakes suggests a mapping from frogs to snakes (perhaps one for each). Latin uses per or pro to describe distributions, Russian po, Greek kata ‘down, along’, Finnish uses kohi ‘toward’ or the ablative case (source case is used for through in Finnish).

One obvious reason for the analogies is that change (motion) is a prime instance of a mapping between two domains (time and space). A path or trajectory distributes points in space to points in time one to one. In practice too, dealing out things to recipients takes the form of a journey of some sort. The event type is a morphism between the two domains which validates the distribution law

\[
p.q \text{ for } t.u = p \text{ for } t.q \text{ for } u
\]

There are dualities about prepositions that may have to do with dualities of morphisms (into, onto, one-to-one). Prepositions in and for are dual in English temporal adverbials.

183 A regular topological space is a Boolean algebra when the complement of a region is restricted to mean its outside (the set theoretic complement of its topological closure). Halmos 1974:13.
Possession

Logically, possession expresses relation composition. I have a son means I have someone as my son equals someone is my son, where son is a two-place relation. From this, we can calculate the logical type of have as a three-place relation between a subject, and object, and a projection of a two-place relation between the subject and object which reduces to that relation between subject and object.

The interesting observation here is that the relevant diathesis transformations match one to one to relation and function algebraic identities: \( x \text{befriends} \ y \) equals (modulo aspect) \( x \ \text{have} \ y \ \text{as friend} \) equals \( y \ \text{is with} \ x \) as friend equals \( y \ \text{is friend of} \ x \) equals \( x \ \text{is friend with} \ y \) equals \( x \ \text{and} \ y \ \text{be friends} \). The as argument identifies the relation as the role or abstract location where \( x \) has \( y \). The relation friend is symmetric so friend = -friend.

\[
x \text{ friend } y = x \text{ friend } y = x \subseteq 1' \text{friend} \quad y = x \cup y \subseteq 1' \text{friend} = x \subseteq 1' \text{friend} U y
\]

Combinatorially, the genitive case corresponds to the infix composition operator \( \circ \) or the combinator B. For instance, monkey’s uncle is representable as the composition of monkey, parent, sibling and male, male\(*\text{sibling}*\text{parent}*\text{monkey}. Here the functions representing one-place predicates monkey and male are test functions, i.e. identity or choice functions so that a monkey is anybody’s monkey, but a non-monkey nobody’s monkey. (Compare the genitive in I am nobody’s fool, meaning nobody can fool me.)

Possession is cross-linguistically framed intransitively as a location event or transitively as its causative. Typically, possession is expressed as an external relation between two pointlike entities: the possessed object is at or with someone, which means that it is in the same place as, or equivalently, in some neighborhood of, the possessor. The possessed is in the possession or under the control of the former. (Latin possidere comes from pos sidere ‘sit in control’). This construction is familiar from Latin, Finnish and Russian: la mihi est, fi minulla on, ru u men’a jest’ all mean at/with me is.

The prepositions at or with denote a similarity relation: a reflexive, symmetrical relation, for instance, together, in the same place. Reflexivity implies the logical truth of \( x \ \text{be with} \ y \) iff \( y \ \text{be with} \ x \), which means that \( x \ \text{and} \ y \ \text{be together} \) somewhere. Thus with is also an adverbial variant of and. To put it the other way round, the reflexive and symmetric adverb with is a variant of the idempotent and commutative operator and. Genitive of is (among other things) nominal variant of possession:

\[
of \quad x: x \ \text{be with} \ y
\]

By our definitions, a genitive is thus an instance of source, subject, and possession, all at once, without being ambiguous or vague. Whether at\[\text{with}\] are transitive, i.e. denote an equivalence relation, depends on the topology of the neighborhoods intended. It is transitive in an indiscrete topology where there is just one equivalence class or neighborhood.

Transitively, possession is framed as causation of (same) location. Somebody has something (somewhere) if they keep it there, i.e. cause it to stay there: I have it in my pocket means it is in with me my pocket, I keep it there. This is a stative causative. More generally, possession may be characterised as caused togetherness.

\[
\text{have } x \ \text{have} \ y: z \ \text{cause} \ y \ \text{be with} \ x
\]

The cause \( z \) can be an external one, in which case we have passive possession, or being possessed, as when one has an illness or accident. When the cause \( z \) is (a subevent of) \( x \) itself, we have an active oblique reflexive or medial frame. Both have and its inceptive get ‘become to have’ are ambiguous between the two senses: one can have/get something from others as well as by oneself. In both cases have and get are inherently reflexive, for \( z \ \text{cause} \ y \ \text{be with} \ x \) entails \( y \ \text{let} \ y \ \text{be with} \ x \).

have inverts the order of \( x \) and \( y \) in the effect, so it is also an instance of subject-predicate inversion. In fact by choosing \( z \) to be the inverse \( x \ \text{be with} \ y \) inversion is the only effect, for the causation reduces to an instance of \( e \ \text{cause} \ e = e \).

\[
 x \ \text{be with} \ y \ \text{cause} \ y \ \text{be with} \ x
\]

Languages have been classified on the basis of which model of possession they have: be or have, and this typology correlated to voice typology at large. Possession with have correlates with accusativity, be with ergativity (Mahajan 1997).

share is closely connected to possession: you and me share something if we have it together or each take a part of it. Etymologically share is related to shear, taking part in something versus taking apart something. The entire family of related notions revolve round the relation of join between one object and two. That in turn is about as primitive a notion as there is, in the same Boolean category with part.
In the nominal domain, possession gets marked on the possessor: **en my pocket**, on the possessed member: **he gih’ath ha’araloth** ‘hill of the foreskins’ or both, **fi minun taskuni, de dem Mann seine Tasche**.

Inalienable possession is nothing but inclusion, the relation of a whole to its parts. If **x be with y** entails **x is disjoint from y**, then a part is **not with** the whole, it is **in** the whole. So one possible story is that languages which treat inalienable possession as a case apart treat possession as disjoint from inclusion. One is **not with** one’s body, but **in** it. Finnish distinguishes between animate ‘loose’ and inanimate ‘tight’ possession with external ‘on, at’ and internal ‘in’ cases: **Naisella on rahaa, autossa on pyörät** ‘the woman has money on her, the car has wheels in it’.

In French, an oblique reflexive is used to express loss of an inalienable possession. A possessive pronoun suggests an artificial leg. Note also the change of auxiliary.

**fr** Elle s’est cassé la jambe. Elle a cassé sa jambe.

**Locating events**

An interesting question relating to location is just **where and when** events happen relative to their participants and subevents. There are clear differences between states and processes here. It is easy to say where and when we quarrel, but it is less clear where and when we love one another. The quarrel as it were happens around us, we take part in it, while we carry the love inside us, it is part of us.

Cases are used to show whether a location is that of the whole event or a subevent. A locative case describes the location of entire event, including the subject. Directional cases describe the location of subevents, including that of the object if any. Finnish is particularly transparent here, using directional cases where English is content with locative ones. Consider a selection of cases from Finnish:

- John etsii avainta pihalla/pihalta. ‘John is looking for the key on (fi from) the yard.’
- John jätti Maryn laivalla/laivalle. ‘John left Mary on (fi to) the ship.’
- Mainos näkyy katolla/katolle/katolta. ‘The ad is visible on/from/to the roof.’

Finnish is able to distinguish between the locations of the event (John) and the key or Mary, respectively:

- John etsii avainta taskustaan (from) pihalla (on). ‘John is looking for the key in his pocket on the yard.’
- John jätti Maryn laivalla (on) pullomereen (to). ‘John left Mary in the ballroom on the ship.’

Such contrasts obtain a natural explanation in terms of event types and thus form evidence for event decomposition.

**Timing events**

Similar questions arise about timing. If I destroy a city by sending off a missile which takes a long time to hit the target, just when do I destroy it? **When am I destroying it? When have I destroyed it? Am I already destroying it when I send off the missile, or only when the missile hits the target?** Am I still destroying it after having let go of the red button? Have I destroyed it before the missile hits? Is the time of the target being destroyed the same as that of my destroying it? If someone ruins the reputation of a public figure by writing a letter which comes out thirty years later, when does he do it? When does it happen? How long does it take? (Bennett 1988:§72).

There are granularity effects here. Some (more or less compact) events have a well defined beginning and are timed by it: **give a speech, go for a walk, take a shower, write a note, climb the stairs (at nine),** other (rather more extended and gradual) ones don’t and aren’t: **build a bridge, develop a tumor, write a book, climb a mountain (?)at nine**. This topic is threshed out in the section on point time adverbials and granularity.

These types of questions call for a closer look at the argument structure of events.

**Change**

The description of change as a succession of states (as a film constituted of still image frames) is too fundamental and obvious to be anyone’s invention (von Wright 1963, Langacker 1987:250). One-place changes depending on the dimension (space) in which the change takes place yield qualitative change and change of place, or alteration and motion. Changes can be instantaneous, gradual or continuous depending on the topology of the space and that of the object undergoing them: The change splits into subevents accordingly. Conversely, complex changes can be concatenated from simple ones.

- **become p**  
  - \( \neg p. \ p : p \)
- **x become p**  
  - \( x \ \neg p.\ x \ be\ p : x \ be\ p \)
- **x change from p to q**  
  - \( x \ be\ p.\ x \ be\ \neg(p \cup q).\ x \ be\ q \)
- **x go from y to z**  
  - \( x \ be\ at\ y.\ x \ be\ at\ \neg(y \cup z).\ x \ be\ at\ z \)
be\|come p \overset{\text{.}}{p: p}

The weaker version be or become of become is noncommittal to what went before p. It is lexicalised in Portuguese ficar and Swedish bli. I use inc for a combinator (morphological affix) defined by

The extraction of the shared subject out of a change is an instance of the binary composition combinator $F$: $F \text{become} = p.p \ x = \text{become} \circ p \ x \ . \ p \ x$.

**Motion**

Motion go is change of place. As the Greeks knew, motion and change are only a subject-predicate inversion away from one another (both were called kinesis by Aristotle). If home and school are adjacent, the path between them in the go formula may be left out. But in the sentence below, they commute with other events:

- **john be not old, john be old** ‘John gets old’
- **john be ~ill.ill~ill** ‘John is temporarily ill’.
- **john be at school, john be not at school** ‘John leaves school.’
- **john be (not at school).at school (not at school)** ‘John goes by the school’.

Interestingly, the last sentence is possible only if John moves between the three places, because John cannot be in three places at once. But a road can, so The road goes by the school does not require that the road moves. We seem to get space-time metaphor on the bargain with no extra machinery.

Motion is an instance of comparative change. This can be proved from the frame by applying the choice function characterisation of comparative to it. The symmetric similarity relation $x \text{ be near } y$ has a topological definition as $x \cup y \text{ be at } n$ for a contextually supplied neighborhood $n$. The comparative $x \text{ be nearer } y \text{ than } x$ according to the choice function characterisation means $x \cup y \text{ be at } n \cap \neg y \text{ be at } n$ for some neighborhood (choice set) $n$.

We can now literally infer from the frame for go that $x$ gets nearer and nearer $z$ as it moves from $y$ through $\neg(y \cup z)$ to $z$. For $\neg(y \cup z)$ is nearer $z$ than $y$ for $n = \neg y$ and $z$ it is nearer $z$ than $\neg(y \cup z)$ for $n = z$. This proof is independent of the topology of space, whether directed, dense, or continuous.

Motion verbs come and go interact with deixis in well known ways. Come denotes motion towards deictic origin (I, here, now) and go motion away from it. Thus come denotes $\neg\text{here.here}$ and go denotes here.\neg\text{here}$. By this analysis here is a built in goal of come and a source of go. Not surprisingly, then, the common complement for come is from while for go, it is to.

Defining away as $\neg\text{here}$, the difference between the event types leave here.\neg\text{here} and away here? $\neg\text{here}$ turns out to be small. We can characterise the transitive verbs enter and leave as come in as go away, respectively.

The event calculus allows proving the equivalence of Slobin’s (1996) verb-framed and satellite framed descriptions of motion events, i.e. that walk from home to school means go from home to school by walking. Recall here that cause is a specialisation of $\leq$ which in turn equals $\langle\rangle\langle$.

$$\langle\rangle\text{from home}\langle\rangle\text{to school}$$
$$\langle\rangle\text{at home}\langle\rangle\text{at school}$$
$$\langle\rangle\text{at home}\langle\rangle\text{at school}$$
$$\langle\rangle\text{at home}\langle\rangle\text{at school}$$
$$\langle\rangle\text{from home}\langle\rangle\text{to school}\langle\rangle\text{by walk}$$

The proof is schematic in that it glosses over cause needed to capture the entire import of by and become to license insertion of get. But it already captures the main insight to be had here. For this is the well known inversion between a manner of motion verb and a manner adverb (a contrast between Germanic and Romance, or Chinese and Japanese, Van Valin 1997:153, Talmy 1985,1991).

A third way to parcel out the event type is with a serial verb construction walk cause go, used in Sranan or Ewe (Kelly/Mellinger 2001:94-95). It is easy to show equivalent to the other two.

Some writers use theme for the shared subject role in a change or motion event type $x:x \ p.xq$.

**Path**

Path joined the inventory of thematic roles at least in Jackendoff (1987) and (1990). My definition above implies that the roles of source, goal, and path are freely interdefinable using the associativity of concatenation. A path is a sequence of positions whose prefix is a source and suffix a goal. Depending on how the sequence is segmented, path lies between
source and goal or includes them. Paths without endpoints are topologically open: the join of two paths is also a path (Verkuyl 1993, Krifka 1998).

Geometrically, a path is a boundary connecting and separating two spaces. Prepositions like along and across relate to that topology: movement along a path stays on the path, movement across it goes from one side to the other. (This description is independent of the dimensionality of the spaces.)

\[
\begin{align*}
\text{along } p & \quad (\text{in } \neg q, \text{in } q) \text{ in } p \\
\text{across } p & \quad \text{in } \neg q, \text{in } p, \text{in } q \langle p \\
\end{align*}
\]

These characterisations make along and across almost dual. The difference is only whether \( p \) separates \( q \) and its complement or meets them. For \( q \text{ in } p \) we get along, for \( p \text{ in } q \) we get across. Predictably, along produces an open event type and across a closed one when \( p \) is closed. The common content seems nicely captured by by. The preposition through is indistinguishable from across on this level of detail. Past is an external case variant of by, past \( x \) means through a neighborhood of \( x \), or by near \( x \).

As a compound role, path seems to borrow its case marking from locatives (en on the road, by the road, a-long the road), or sources (fi partitive tietä (orig.) of the road, elative ovesta ‘from the door’, de genitive geraden Weges ‘by the straight route’), or goals (de accusative den Weg entlang, durch die Tür ‘along the road, through the door’).

**Direction**

Directions are definable from paths: one goes toward the city if one is on the way to it.

\[
\begin{align*}
\text{John is on the way to the house} \quad & x \text{ in } w: (w = \text{at house, } w \text{ at house)} \\
\end{align*}
\]

This characterisation does not entail that John gets to the house, only that the way does. Whether he does depends on whether he keeps on the way all the way. Time is the independent variable here, so the path \( w \) we are dealing with here is an event type rather than an object. A better term for it is trajectory or journey. If we set \( w \) to \( x \), the event type reduces to \( x \text{ in } \langle \neg \text{at house, at house} \rangle \), which equals the medial event type \( \neg \text{at house} \langle \text{at house} \rangle \). Interestingly, this event type does not entail that John is in motion. The event type is a simple state. This will help understand a related type of progressive in Norwegian.

A difference between the prepositions to and toward is that the former entails at, the latter not: one who goes toward a place is only getting near it. Knowing that at entails near but conversely, we can infer John walked toward the house from John walked to the house, but not vice versa. This accords a second characterisation of direction through near. Remember that near is a comparative notion (nearer), the superlative next indicating adjacency.

\[
\begin{align*}
\text{John goes to the house} \quad & \neg \text{ at house, at house} \\
\text{John goes toward the house} \quad & \neg \text{ near house, near house} \\
\end{align*}
\]

The two characterisations of toward are interdefinable by taking the neighborhoods for near to be factors of the event type way. To wit, the notions to near \( p \) and begin to \( p \) are equivalent, both denote the event type \( < \langle p \rangle \). Similarly the event types next to \( p \) and almost \( p \) which denote \( < \langle p \rangle \). This is just the difference between interior and point progressive. The characterisations of toward in terms of way or near allow an oblique approach. For instance, a road can go toward the city without always pointing directly at it. Resolution comes in here as well. A road can locally even point away from the city, as long as the endpoint is nearer it than the beginning. Then we can infer that it mostly points toward it.

A vector can be specified by giving its endpoints, or equivalently by a direction and length. The direction can be given by a unit vector, or an angle (length of unit arc) to another one. There is a morphism from this representation to event types too. The event types

\[
\begin{align*}
\text{go from a to b in a by b} \\
\text{go from a toward b for b by a} \\
\end{align*}
\]

are dual and equivalent. The first event type says the distance \( a \text{ by } b \) is coextensive with a closure of go, the second says an open cover of go is coextensive with the distance \( a \text{ by } b \).

**Flow**

Flow is the time and space continuous motion of a stream through a place. The motion of each part (or particle, if the part algebra of the flow is atomic) is continuous in time. At the same time the entire stream is continuous and directed in space by the direction of the motion. The stream can be visualised as a three-tape automaton, the three tapes of objects, places and times flowing through at arbitrary but continuous pace:

\[
(x \text{ at } p \text{ at } t) = x \text{ at } p \text{ at } t = x \text{ at } p \text{ at } t = x \text{ at } p \text{ at } t
\]
The three-way continuity means that adjacent places are occupied by any part at adjacent times, and by adjacent parts at any time, and adjacent parts pass any place at adjacent times. The first condition is the temporal continuity of motion of particles. The second condition is the spatial continuity of lines: paths, roads, river beds and the like. The third condition is the continuity of the mass flow.

A river is the same and different at any time, you can’t step twice into it, as was already pointed out by Heraclit (504 b.C.), another duality freak. Flow is the characteristic motion of a sea of waves as well. A wave front appears to move at once forward and stay in place. Because of its double continuity, a flow has the aspectual properties of a state and a result by locating them in the argument structure of a verb. I shall bend Dowty’s analysis of process, change and result by locating them in the argument structure of a verb. I shall bend Dowty’s analysis of process, change and result by locating them in the argument structure of a verb. I shall bend Dowty’s analysis of process, change and result by locating them in the argument structure of a verb.

**With or against**

One striking thing is how close the opposites with and against come in language. Prepositions easily switch sides etymologically. Withstand means oppose. English with is cognate to German wider ‘against’. Latin con-tra ‘against’ is cognate with cum ‘with’. Latin ob ‘against, toward’ is found in both oppose and offer. Greek kata ‘down’ can mean both along with and against. This should not be curious given the distance between complementaries is one bit. It remains to consider just what it means for with and against to be contrary.

The notion of opposition has come up here and again. In the last analysis, opposite is one of the **megista gene**, characterised by combinatorial laws like involution (two wrongs make one right) and zero-sum (the sum of opposites is zero).

Forces oppose one another when their vectors are opposite, and relative motion prevented when they sum to zero. Players oppose one another over plays when their preference relations are converse, so the corresponding utility measures can be chosen to sum to zero. Victory is prevented when the value of the game for both players is zero.

The close affinity of with and against becomes clear when one considers the small distance between cooperation or resource sharing and competition or resource conflict. In both cases two players want the same thing. The difference is whether they can both have it at once. Resource conflict happens when what two want can only be had by one. If one has it the other one does not. Hence if one wants it he must want the other one not to have it.

Bringing in the shared resource as the tertium comparationis explains the close similarity and definite difference between friendly and hostile behavior. In both cases, the players approach one another in quest of what both want, in fact come together over it. The race ends and competition starts when both can no longer occupy the same place: attraction turns into repulsion, pushing and jostling. Fighting against someone is at once fighting with them.

Further combinatorics is obtained when the players are mutual resources to one another, or one is a resource for the other. The former case is symbiosis, love if you want. Lovers want one another, want to be together, want to become one as Plato had it, or three perhaps. The latter case is chase, eat or be eaten. The predator/parasite likes its prey/host, wants to become one with it, but definitely not vice versa. The difference between a loving embrace and a deadly one, a hit and a pat is in the outcome.

The difference between self-serving and other-serving love depends on choice of unit as well. If our utility functions are identical, one acts for oneself just when one acts for the other.

Coming down to brass tacks, what is the minimal semantics of against? Who is with us is on our side. Who is against us is on their side. The saying who is not with us is against us tries to exclude the logically possible tertium of being on nobody’s side, sitting on the fence, on no man’s land. What we need here is a minimum topology of two regions separated by a third.

\[ x \text{ be with } y = x \text{ and } y \text{ be in } z \]
\[ x \text{ be against } y = x \text{ be in } z \text{ and } y \text{ be in } \neg z \]

If \(x\) is neither with nor against \(y\), then \(x\) is neither in \(z\) nor in \(\neg z\), but straddles the fence.

**Transitive**

Transitive is the traditional name for binary causative event types (Hopper/Thompson 1980). The term means going over (transire). The cause-become analysis of transitivity goes back to Stoic philosophy: “a cause is a body which does something or other and by doing so brings it about that another body is affected in such a way that something comes to be true of it” (Luhtala 1997:95).

Numerous compositional analyses of transitivity in the cause-become genre have appeared since, including McCawley (1968), Lakoff (1970), Dowty (1979), Parsons (1990), or Van Valin (1993). Dowty’s analysis details the relationships of process, change and result by locating them in the argument structure of a verb. I shall bend Dowty’s analysis somewhat to fit it into the format followed here.
In outline, John hammered the metal flat has the structure

**John hammer metal cause metal become flat**

where the hammering event and the flattening event are overlapping processes which may be composed of smaller bits of some hammering causing some flattening. Looking at one bounded bit, it is likely to consist of a bang with the hammer causing and followed by a dent in the metal. Each individual bit denotes a sequence a causing event and a caused event. In the limit, the cause and effect come interleaved so as to form a connected event of one process or state maintaining (where stay replaces become in the formula). Thus cause in general denotes a pair of two overlapping or successive events, cause and effect. From the point of view of the particular causal chain in question, the cause is an irrisolute event, a process or cycle involving the subject, not a change in it.

Relating kill to cause become not alive need not equate them. Kill says more than cause to die. Some of the semantic options open in the paraphrase are already committed in lexical causatives. Typically, transitive verbs lexicalise further conditions on the causal chain (manner, instrument). For instance throw means cause to fly by a particular method. Cause to fall does not exhaust the meaning of fell; there are further constraints concerning the method. Many transitive verbs involve manipulative causation (Shibatani 1976): there is a physical (manual!) contact between the subject and the object of the causation. Besides, a transitive verb does not allow all the same possibilities of modification as its causative paraphrase, already because there are fewer words to hang modifiers on. Kill alone cannot mean cause to die alone. Almost kill does not have to decompose to cause to almost die in order to cover that special case.

The causative analysis of transitives can be extended to intransitive manner of movement verbs by representing them as reflexive causatives: one who walks home causes himself to get home by walking:

**John walk cause john go home**

This analysis is supported by the observation that intransitive movement verbs in many languages are medial: classical Greek *poreuomai* 'travel', Latin *progradior* 'progress'. Compare section on agentive reflexives below.

The prominence of the cause become schema should not hide the fact that the modal connective cause is aspectually transparent. This is apparent from its counterfactual definition, which only requires that the cause not follow the effect. The aspect of a transitive causative comes from the events that it connects. There are open and closed causatives. For instance, *keep or hold* are open causatives, whose logical form is cause stay rather than cause become.

Aspectually different types of transitive causatives can be distinguished in terms of the aspect of the cause and effect: permanence causatives of form a cause a, e.g. *hold*, process accomplishments of form a cause e, e.g. *build*, result accomplishments of form e cause b like break, and change causatives of form e cause e like give. The last mentioned type is inherently least marked for aspect, taking its character exclusively from its arguments: *you gave me a start* (achievement), *you gave me strength to go on* (permanence).

**Means and instrument**

The event John hammers the metal can be subjected to further analysis of the same kind: John uses the hammer to work the metal, i.e. John does something with the hammer so that the hammer does something to the metal. This splits the hammering event into subevents of John doing something to the hammer and the hammer doing something to the metal. The first one is an agentive causation, the second one an instrumental one.

**John cause hammer cause metal become flat**

This formula seems a good approximation of what it means use the hammer on the metal or do something with the hammer to flatten the metal. The choice of prepositions meaning through or by is licensed by the fact that in a causal chain, the effect passes through or by the instrument. The choice of prepositions meaning (together) with is licensed by a schema of the logic of causation that allows conjoining successive causes in the chain into one (compare cautious transitivity of van Benthem (1991)).

\[
p \text{ cause } q \text{ cause } r \quad p \cap q \text{ cause } r \quad p \text{ cause } r \text{ with } q
\]

Stipulating that comitative with is an adverbial variant of meet, we get the formula on far right. We thus find a logical motivation of the appearance of both by and with as instrument cases across languages in the transitivity of causation.

The instrumental verb *use* has two common argument structures. One is the English type, the other the Latin one (Genusiene 1987):

\[
p \text{ use } q \text{ to } r \quad p \text{ cause } q \text{'cause } r
\]

\[184\] The conditional cannot be strengthened to an equivalence, for instance, the hammer does not flatten the metal with John.
\[ p \text{ use } 1 \text{ with } q \quad p \text{ cause } 1 \text{' cause } r \cap 1 \text{ cause } q \text{ cause } 1 \]

The English one singles out a prefix of the causal chain, turning the instrument into an object and the rest into a final clause. The Latin deponent verb *uti* is an antipassive which turns the verb into a reflexive and the means into an oblique. An English paraphrase would be ‘make oneself use of’. Lithuanian has both *Mes naudojame elektram / Mes naudojames elektra* ‘we use / make use of electricity’ (Gemisoni 1987:70).

The *use* schema details the combination of a process and a change *pnic* involved in the definition of an accomplishment. It also makes it more definite what it means for a process to be the process of an event, as required in the definition of the progressive. The causal chain provides the glue between an event and its progressive form that Galton finds impossible to capture in purely temporal terms (Galton 1984:145-149).

Instances of the *use* schema are noncommittal about resultativity: using the hammer to flatten the metal does not guarantee the metal gets flattened (the imperfective paradox). The *use* schema is a common source for process accomplishments which are vague between accomplishments and activities.

Lapolla/Van Valin (1997) observe a finer distinction. *Eat with a spoon* does not entail that the spoon eats. The spoon is instrumental in the food’s motion to the mouth, not an intermediary eater. Picking *eat* apart a little deeper, we find something like \( x \text{ cause } spoon \text{ cause } food \text{ go into } x \). This does not entail that the spoon eats, or *spoon cause food go into spoon*. We need not conclude that the spoon is a different type of instrument here, outside the causal chain.

### Causal roles

Given transitivity, causation is associative, it is fair to out parentheses and treat *cause* as an infix operator: This gives us a *causal chain* of events. A nice consequence of associativity will be that a causal chain can be divided into causes, effects and results in many ways. This makes *cause* look very much like the concatenation operator. In fact, causation has a temporal projection definable in terms of concatenation. This projection is the traditional rule *propter hoc ergo post hoc*:

\[ p \text{ cause } q \subseteq p \leq q \]

In words, the cause and effect are included in the causation event and the effect does not precede the cause. The temporal asymmetry of cause and effect (the direction of ‘time’s arrow’) is another facet of the asymmetry of time: saying cause cannot follow effect amounts to saying that what is once past cannot be changed, while what is yet to come can (von Wright 1973). It follows that the initial cause is a prefix of the causal chain and the effect is a suffix. It also follows that final state of the final change is also a suffix of the causation, in other words, it is a result of the causation by my aspectual definition.

The causal chain of events allows defining a number of central thematic roles (Croft 1987, Lapolla/Van Valin 1997). *Cause* and *effect* were already mentioned as the event arguments of a causation. Now they can be generalised to initial vs. final suffix of a causal chain. An intermediate chain could be called a *means or method*. Recalling how we defined *source, path* and *goal* before; we can further regard a cause as a *source* of the change, a means as a *path*, and an effect as a *goal*. *Result* has been defined earlier as an open suffix of an event. This definition can stand.\(^{185}\) The subject of a cause may called a *cause* too. An *agentive* causation is one whose prefix is a reflexive mental event; the subject of this event is the *agent*. The subject of the final effect is the *object*.\(^{186}\) Subjects (and objects) of intermediate causes are *instruments*.

\[
\begin{align*}
\text{result} & \quad e: < \text{ become } e \\
\text{cause} & \quad e: e \text{ cause } < \\
\text{effect} & \quad e: < \text{ cause } e \\
\text{means} & \quad x: < \text{ cause } e \text{ cause } < 
\end{align*}
\]

Causation is also transitive in the logical sense (Miller/Johnson-Laird 1976, Bennett 1988:46.47): the initial cause causes the final effect, so it is true to say that in the end, it was John who caused the metal to be flat, i.e. *John flattened the metal*. Other truths supported by the chain are *The metal got flat, the hammer flattened the metal, John flattened the metal using the hammer, John used the hammer, the metal got flat by hammering, the metal was flattened using a*

---

\(^{185}\)The causal analysis only confirms the Aristotelian point that an activity is its own result: for instance, standing (being upright) is the continuous effect caused by an equally continuous simultaneous effort of keeping oneself upright.

\(^{186}\) I reserve *patient* for animate goals like *I in I like it*. The role name *affected* has been suggested for a goal of a change which is not the subject to the change. Frawley (1992:212), Wilkins (1988).
The notion of effect is related to the notions of result and consequence. In my explication, effect is an event caused by an event, result is an open suffix of an event, and consequence is a subsequent event contextually implied by an event. The last mentioned notion is involved in current relevance. For instance, write a book is an event whose effect is that a book came about, whose result is (that) the book is there, and whose contextual consequences may be that the author knows the subject, can write books, is famous, or whatnot.

Dynamics

Dynamic concepts are needed to tackle verbs denoting the application of force like push, pull, press, hold, draw, drag, stretch, jump, throw. There are two aspects to dynamic: one contrasts dynamics to statics (motion/time involved or not), the other contrasts dynamics to kinetics (mass/energy involved or not). It is the latter sense that is discussed here. My hypothesis is that the same classical mathematics can be used to model physical motion and human motives (Strogatz 1994, Sprott 2001).

The analogy is reflected in the aspectual properties of the shared vocabulary of action and causation. Geometric (position, distance) and kinetic (motion, acceleration) event types are intransitive. Mechanical ones (force, energy, power, impulse) are transitive, agentive, and causative. One who wants something is attracted to it. If one is not at the goal, one strives toward it, if one is there, one is reluctant to relinquish it. Whether one is able to reach the goal depends on whether one has the potential, the energy to reach it. In order to get there, one must at least try to set things going toward it, i.e. apply some force to it for some time to give it an impulse for it to gather momentum. If there is continuing opposition on the way, one has to keep working, apply power, expend energy until either the goal is reached, or one meets an obstacle one has not enough power to overcome, or one runs out of energy. (Though some of this terminology is modern, Newton and his predecessors did not invent mechanics from thin air.)

The aspect types of the concepts involved are predictable from their definitional relationships. Ability (potential energy) is a disposition: a state. Activity (power) is use of energy per time: a process. An object is in motion by giving it an impulse (application of force for a limited time): a cycle. Starting and stopping (acceleration) are (gradual) changes between rest to movement. Movement is ambiguous between a state of change (velocity) and change of state (displacement). The goal (position) is again a state.

Even the practical syllogism has a mechanical analogue: If an agent wants to do something and is free (able to do what he wants), he does it. If a force applies to an object and the object is free (there is less force in the opposing direction) the object moves. One can find out what someone or something wants by where it goes when it can move freely. If it goes nowhere it is happy to be where it is.

There is a conventional split in our thinking between causation and agency, effective and final causes. Causes precede effects, reasons follow them. Causal push is contrasted with teleological pull. The difference thus involves time’s arrow (Reichenbach 1956).

Force is related to motion counterfactually in the way described by Newton. In the absence of equal or stronger counteracting forces, a push or pull gives acceleration which with time causes velocity, i.e. motion. If two objects exert a pull, then they tend to come closer, if they exert a push, they tend to move away. ‘Tending’ is the counterfactual element of force: if objects are free, i.e. nothing stops them, they will move. Thus pull means cause to come near if free or try to cause to come near. In general, the notion of dynamic can be explicated as factual or counterfactual change.

Mass does two things: it opposes forces (inertial mass) and it pulls (gravitational mass). Among the important analogies in dynamics is Einstein’s $E = mc^2$, which equates mass and energy. Other analogies follow from it: between density and force (mass or energy per space), between flow and power (mass or energy per time).

To complete the analogy, we must bring in information. Information is uneven distribution of something. Its dual, entropy is even distribution. Uneven distribution of mass causes potential differences, or energy. One thing carries information about another when it varies with it. What I want to get a handle on is the saying knowledge is power: a clever player of a game is equal to a strong one. Information is analogous to mass and energy. Information per time, or channel capacity, is analogous to power.

The correspondences show in many places: easy means light, slow, soft, or simple; difficult means heavy, fast, hard, or complicated.

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187Transitivity of causation may seem odd given that counterfactual conditionals are not. But counterfactuals fail transitivity when the context shifts from one step in a chain to the next. This does not happen in a causal chain because causes are factual.
**Push and pull**

The verbs *push, pull, hold* denote forces. As Newton suggests, their semantics is easiest to give counterfactually, by their effects on objects which are free to move. An object is free if nothing prevents it from moving. More generally, one is free to do something if nothing prevents it from doing it. (Note directions from and to here.) Thus, free can be defined by

$$\text{free to e: } \neg \langle \text{cause } \neg e \rangle$$

One is free to do something when nothing prevents one from doing it. We can define *push, pull* and *hold* implicitly as follows:

$$\sigma y \text{ free} \to (x \text{ pull } y \text{ cause } y \text{ become near } x)$$  
$$\sigma y \text{ free} \to (x \text{ push } y \text{ cause } y \text{ become } \neg \text{near } x)$$  
$$\sigma y \text{ free} \to (x \text{ hold } y z \text{ cause } y \text{ stay } z)$$

Corresponding explicit definitions are given by

$$\text{pull: } p: \sigma y \text{ free} \to (x p y \text{ cause } y \text{ become near } x)$$  
$$\text{push: } p: \sigma y \text{ free} \to (x p y \text{ cause } y \text{ become } \neg \text{near } x)$$  
$$\text{hold: } p: \sigma y \text{ free} \to (x p y z \text{ cause } y \text{ stay } z)$$

(Well, we can also pull something away from us or push something toward us, using our limbs. But then these definitions apply to the limbs. Talmy 2000a:464)

Force is thus a hypothetical or counterfactual cause of motion. It is hypothetical because if other causes are present, they may prevent it from actually causing motion. Define *try* as a prefix operator on the prefix of a counterfactual causation schema:

$$\text{try e: c: } \sigma \to c \text{ cause } e$$

where $\sigma$ is a counterfactual strategy (the subject’s plan, for instance). One who tries to cause an event does a hypothetical cause for it. Applying this definition to the definition of *pull*, we can see that *pull* literally means *try to move toward self*. In English, *tend* is more accurate than *try* when the subject is inanimate. Going ahead of matters, *try* attributes the hypothesis to the subject.

$$\text{try e: x plan (p cause e) cause p}$$

**Newtonian events**

In this section, the goal is to define a morphism between a Newtonian account of dynamic events and a description of them in the event calculus. Combining the above definition of forces with my definitions of differential events, we can actually prove that the definition of pushing above corresponds to the Newtonian equation that impulse $I = Ft$ causes momentum $p = mv$. What I mean to prove is that provided $y$ is free,

$$\text{x push y for t } F^t$$

entails

$$\text{y move } d \text{ in } u m^d/u$$

where $d$ is a distance and $u$ a time. The proof: assume *y free*. Then by the definition of *push*,

$$\text{x push y for t cause y become } \neg \text{near x in } u$$

i.e.

$$\text{y go from near x to } \neg \text{near x in } u$$  
$$\text{y move } \neg \text{near x \near in } u$$

This can be considered qualitative Newtonian physics. To make it quantitative, we ought to fix weights and measures. Next take the familiar case of a billiard ball hitting another. Again we assume *y is free.*

$$\text{x move\} } \neg \text{ y move\} x hit y cause x stop\} y start.}$$

The event types *move, stop* and *start* can all be construed comparatively, i.e. applied relative to a norm (context or choice set). Then all our qualitative physics is saying here is that (relative to the given frame reference), $x$ moves faster than $y$ before the collision, while after it $x$ slows down and $y$ picks up speed. We may unpack *hit* as
x move to y cause x push y

Here hit is an impulse, a force for a time, which gives a mass a velocity, or momentum. Impulse and momentum is the same quantity, viewed differently. The principle we are modeling here is the law of preservation of momentum, i.e. the momentum of the system is the same before and after the collision. Since y was at rest, the momentum of x must be now divided between x and y. Since x pushes y and y is free, y gains momentum. Given preservation, x must lose some. Equivalently, by Newton’s third law, y pushes x, so y gains momentum in the direction of the push (away from y), which means x slows down.

What have I got here is a sketch how to map between natural language event types and Newtonian physics. It does relate the concept of cause to Newtonian mechanics: causation is application of force. An example is the event type of push: the push is an application of force, which causes motion.

What is taken to cause what depends on the ascription of forces and masses to the particles. That in turn is inferred from other similar situations on the basis of overall simplicity of the ascriptions.

For instance, in an elastic collision of two billiard balls, the moving ball causes the standing ball to move, while the standing ball causes the moving ball to stop. It is fair to say that the moving ball overcomes the resistance of the standing ball, while the standing ball blocks the moving ball. (Which ball moves and which one stands in turn depends on the chosen frame of reference.).

How we describe a given situation in event types depends on the relative magnitudes of the masses and accelerations. It is a matter of granularity, in fact. When a sperm whale whacks on the planet, we say the planet stops the whale and not that the whale starts the planet. Both happen, but the granularity is too different for both to deserve notice.

**Talmy vs. Newton**


Newton’s first law is admittedly unintuitive: rest and simple motion do not require energy, acceleration does. Common sense is right here, for by the second law of thermodynamics, unaided motion does run to a stop eventually. Constant velocity can only be sustained by a flow of energy, which cannot go on forever. A related unintuitive bit is that a force uses up no energy until it moves something. We feel different, but of course we do move inside when we try moving things.

Pace Talmy, Newton’s third law does not rule out unequal parties. Blocking and letting, resistance and overcoming can be characterised under it. Although the action and reaction are equal, their effects on the participants (their accelerations) can be different, as they are a function of the masses and other forces present.

A truck and a car hit one another with equal force, but the truck wins because it has more mass. If I pull on a locked door, I do feel a pull. Yet it is me who pulls, not the door; my energy is being expended. When a book leans on a shelf, we don’t say the shelf leans on the book. There is a counterfactual in lean: in the absence of the support, the book would fall. The book’s weight is canceled by the shelf alone, but not vice versa, the shelf has other support.

In fact, the third law is implicit in Talmy’s (2000) notion that in natural language, every action has an opposition. Talmy finds typical of causation in natural language an opposition of two forces, one of which wins out. Otherwise the opposition would win and produce the opposite effect. By Talmy’s principle, a sufficient cause a cause e can be strengthened to a counterfactual necessary cause ¬a cause ¬e. Going from effects to their causes, we obtain the equivalence

\[ a \text{ try e if and only if } ¬a \text{ try } ¬e \]

Thus Talmy’s zero-sum principle turns out to entail a restatement of Newton’s third law in the event calculus.

Talmy claims that the notion of an agent has no counterpart in physics. I disagree. Agency is explicated by the notion of open vs. closed system: an agent is an energy source in an open system. One component of the net force operating on x is the force exerted by x on itself, which need not be 0. To say that a system of particles is closed amounts to saying that this force is 0. (Montague 1974:317). Newtonian mechanics does not care what causes what (it is symmetric in time, Reichenbach 1956). That is decided in casu by considering the actions of agents unexplained, i.e. leaving the system open about its agents.

There is an interesting point of coincidence: Montague (1976) lets f(x,x) stand for the force exerted by a particle on itself, interpreted as a force external to the system. I will suggest interpreting agency as reflexive causation. For parties in the system, forces coming from outside of the system will appear the same as free agency would, because neither can be explained by forces within the system. So “agent internal force” and “system external force” are dual! An open system and a system of agents with internal state appear just the same. Soul moves by itself or is moved by God, no difference.

Newtonian physics is deterministic only if we are studying a closed system. The behavior of an open system is unpredictable. But the same holds of (simple) games. A player has a choice only as long as his preferences are
disregarded. When the game has been solved, the play is deterministic (up to indifference). Aristotle's definition of free will fits this picture: an agent has free will when he can do what he wants. It is complemented by Dostoyevsky's point about free will: the will is free only insofar as it concerns irrational choice between indifferent alternatives. To decide who is responsible in a situation equals deciding whose actions are explained by reference to internal or system external causes.

My approach is to look for translations between perspectives on events. I believe Talmy's valid insights on natural language dynamics can be captured without compromising physics.

**The event type of a game**

The ideas of the previous section can be generalised. Talmy's force dynamics can be represented in my calculus by characterising a notion of a (zero-sum) game as a complex event type. A game is described by giving player preferences and strategies. For the purpose of classifying natural language event types, it is useful to follow game theory and distinguish between one-person, two-person and n-person games. One-person games characterise animacy, two-person games characterise animate communication, and n-person games characterise social interaction.

A one-player game, or game against nature, is basically a decision situation, where an agent has a number of actions which have alternative outcomes depending on Nature, a supposedly disinterested player. Solving a one-player game is an optimisation problem. It does already involve planning future actions, making choices on the basis of preferences, and calculating their expected gain, so it introduces all the game modalities characteristic of animacy.

Genuine game-theoretical second guessing of opponent plans based on an assumption of mutual information starts with two-person games. In a zero-sum game \(g\), the preferences conflict (their sum is the event type \(\emptyset\)):

\[
x \text{ want } e \quad y \text{ want } \neg e
\]

For the event type to be a game, the two players must have free choice: at least two moves, and the players must have control over them (eadem potentia):

\[
x \text{ can } p \quad x \text{ can } \neg p \quad y \text{ can } q \quad y \text{ can } \neg q
\]

The strategies must be pairwise compatible, so that an outcome of each strategy combination exists. For instance,

\[
p \leftrightarrow q \text{ cause } e \quad p \vee q \text{ cause } \neg e
\]

Next, we must specify the players' information about the play. Since the future is open, knowledge only concerns the past - the players can't know what will happen or what everyone is going to do. They may or may not remember or perceive what has happened or is happening in the game when they make their move (this includes their own earlier moves).

In the example game at hand, this knowledge is crucial for solution of the game. If the players move without knowledge of one another, neither player can win. But if \(x\) knows \(y\)'s move, then he can win and \(y\) can't help losing. For then \(x\) has four strategies against \(y\)'s two, and one of the four wins against both of \(y\)'s. The winning strategy for \(x\) is the strategy \(\sigma\) which implements \(p \leftrightarrow q\), i.e.

\[
y \text{ q cause } x \text{ p } \text{ f } y \text{ } q \text{ cause } x \text{ p } .
\]

In order for \(x\) to have this strategy, to be able to cause this event type, \(x\) must know whether \(q\) or \(\neg q\). This can be rephrased without reference to knowledge as follows. \(q \text{ cause } p\) means a counterfactual theory \(\tau\) passes information from \(q\) to \(p\), i.e. \(\tau\) prefers (increases the probability of) \(p\) given \(q\). In two-valued logic, when \(\tau\) trivialises, this means the classical conditional \(q \rightarrow p\) holds.

Finally, the players must have complete shared information about the rules of the game.

\[
x \cup y \text{ know } g
\]

Assuming know is transitive, this mutual knowledge postulate iterates to arbitrary depth, lending support to genuine game theoretical reasoning about \(g\) (Carlson 1994). This too has an inanimate analogue: a game is a homeostatic system with feedback (Ashby 1956). The game is solved when the system runs to an equilibrium, i.e. reaches a saddle point.

The event type \(g\) just described is an intensional, algebraic dual of the extensional Urbild of natural language mood drawn in the chapter on mood. It allows defining an array of derived event types and roles associated with agency and animacy.

For instance, the event types and roles introduced in Talmy (1985, 1987, 2000) under the name of force dynamics can be characterised on the event type \(g\). The event types win and lose are immediate: \(x \text{ win } g\) is the event type \(e; g\) and \(x \text{ lose } g\) the event type \(\neg e; g\). The force tendency is \(\sigma; g\). The force tendency is toward rest if \(e; g\) is an open event type and...
toward action if \( e : g \) is (half)closed. The event type of \( x \) being the stronger entity is \( x \) can win, which equals the event type \( x \) have \( \sigma g \).

Armed with these definitions, we can algebraise Talmy’s diagrams in the event calculus. Depending on the event type to describe, we identify the roles of agonist and antagonist respectively as \( x : g \) and \( y : g \) or vice versa. For instance, Talmy’s (2000a:415–416) event type (3c)

The ball kept lying on the incline because of the ridge there
where an agonist has a tendency toward change but the resultant is rest is a subtype of

\[
x \text{ lose } g : x \text{ want } c \text{ in } g
\]

where \( c \) is a change. This event type can be proved to entail the event type \( x \) fail \( c \). We will also be able to prove, using the definitions of active and passive event type, that this event type is passive (the agonist is not the cause of the event, but a subject of an effect.)

**A game of pursuit**

This section relates dynamics to animacy. I do it by constructing a small game with inanimate players. Among other things, this game will provide an event type for the animate subject verbs *chase* and *flee*.

I first give a typical play of a game of pursuit a physical explanation. Then I factor the forces anew by abstracting away some of the forces, to make it look like a game. The physical game of pursuit makes a point about animacy. The point is this: the animate model of explanation is a way of factoring forces in a physical system. Not another, competing model of explanation.

The game I shall describe is a game of pursuit (Isaacs 1965). There are two players who want opposite things: A fast but heavy one, a wolf called Romeo, is attracted to a rabbit, light but quick, call it Juliet; but Juliet is repelled by Romeo. The light player pays close attention to its opponent, the heavy one does not. This means that the Juliet’s next move is sensitive to Romeo’s previous move, while Romeo’s next move depends of its own previous move. Mathematically, both players’ differential equation has a significant factor for the big one.

Romeo’s faithfulness to his own earlier values means he is more predictable on the basis of his own history. Juliet may seem unpredictable if one looks at her own earlier behavior, but she is predictable from earlier values of Romeo. Here, the dependence on one’s own earlier position is an inertia factor. Dependence on the other’s earlier position measures forces of attraction and repulsion. For Newton, the inertial factor is none else than mass. The effects of the forces of attraction and repulsion depend on the masses. For a heavy player, the inertia is large, the accelerations slow, the forces large. For the small one the inertia is small, the reactions quick.

So far, there are simply two forces at play: an attraction between a heavy particle and a light one, and a repulsion between the two as well. When they are far away, the attraction wins. When they are close, the repulsion wins: the light player bounces away. But soon the heavy one comes on again. Both forces get stronger as you get closer, and weaker as you get away. But when the players are close the repulsion is stronger, and when they are away the attraction is stronger. An oscillation arises until the forces are in equilibrium. The game stops when and where the forces are balanced. This defines the trajectory of the pursuit.

Talmy’s point was that there is no attraction without an equal opposite attraction, and no repulsion without an equal opposite repulsion. Physically, the forces between the players are impartial, neither is particularly bound to either of them. The animate game arises from associating one of the forces to one player, the other to the other player: one wants to come close, the other wants to get away. This is what it means to factor forces for animacy: we treat the objects as agents by discounting their causes. The one that is moved is the one that feels the force, the other is the agent, the unmoved mover.

Let us see how to construe the pursuit event as a game. The wolf has not only the attraction to the rabbit, it also has the handicap that it can’t turn too fast, either because if he turns too fast his feet slip or because he cannot produce enough power to produce the acceleration. So his trajectory is constrained by his current momentum. That constraint can be construed either as a lack of support, so that all force beyond the point of slip goes wasted, or as his lack of power to make a sharp turn in full speed.

The rabbit, in turn, cannot run as fast but boy can he turn in full speed. And not only he can turn, but he has the built in constraint that he must and will turn, when the wolf is close enough. It is as if it had power steering, so that if the wolf gets close enough with ever so little a sideways bias, the rabbit multiplies that bias. The outcome is that the rabbit turns sharply when the wolf gets close.

The mathematical point is that we can factor the forces governing the motions of the particles in two ways. One is a solution of a (linear) differential equation on the sum of forces between the particles, one of attraction, one of repulsion. The trajectories are deterministic for any given starting point.

a. **Attraction:** \( F = ax + b \)
b. Repulsion: \( F = cx + d \)

Romeo goes fast but turns slowly, Juliet goes slow but turns quickly. Juliet reacts at the last moment and seems just slip out of the way of Romeo, who comes on strong but reacts at a delay. Romeo has more energy but Juliet has more information on him. Knowledge equals power.

The other way is a game between two players: one is attracted to the other, the other repelled from the other. The player’s motions are constrained but not unique relative to a given starting point. Romeo’s strategies are constrained by not being to turn fast, Julie’s by not being able to run fast.

c. Romeo: \( \frac{dR}{dt} = aR + bJ \)

d. Juliet: \( \frac{dJ}{dt} = cR + dJ \)

e. Constraints

The constraints tell that \( a \) is a large forward factor, \( b \) is directed toward Juliet, \( c \) is large and directed away from Romeo, and \( d \) is a small forward factor. For a small forward \( d \), \( c \) gives Julie’s flight a large perpendicular component. This factorisation represents a differential game (Isaacs 1965). The value of the game is the minimax value of the game under the constraints.

\[
\min y \max z H(s).
\]

Solving this game gives deterministic differential equations that predict the trajectories of Romeo and Juliet. The optimisation takes up the slack left by the constraining inequalities.

The trajectories of Romeo and Juliet represent a play, the outcome of their optimal minimax strategies in the space of possible motions consistent with the constraints. The forces of attraction and repulsion between them represent their preferences: As usual in games and life, one cannot get exactly what one wants. The combined play may be far from what each player’s preferences would predict alone. If the game is one of imperfect information, game theory recommends Julie a mixed strategy which randomises her motions (Miller/Cliff 1994).

Simple differential games are solved very fast: either the oscillations are damped and die out, or they go into a loop, or they diverge and get out of hand. In the first case, P captures and wins, in the second, there is a draw; in the third, E escapes.

To have an example of a solution of the game, simple linear damped oscillation is the solution

\[
\frac{d^2R}{dt^2} + \beta \frac{dR}{dt} + \omega^2 R = 0
\]

where damping \( \beta = -a - d \) and frequency \( \omega^2 = ad - bc \) (Sprott 200?). If Romeo and Juliet move perpendicularly in damped harmonic motion, Juliet sidestepping Romeo’s approach, Romeo’s trajectory appears to draw tightening ellipses round Juliet: Romeo is chasing around Juliet.

Altogether we have here a) preferences and b) strategies. The utilities are expressed by the forces of attraction and repulsion, the strategies are expressed by the constraints on motion. By an optimisation, we get a completely deterministic description of the pursuit behavior.

The mutual attractions and repulsions explain the general direction, and the constraints explain the trajectory. Because of the constraints, the game space is curved, and the maximum is not found straight ahead as it would if the players were free to move by the forces of attraction and repulsion.

We can say that the wolf can't help continuing much the way it is going, and we can even say that the rabbit knows that - in the sense of having been adapted to it through generations of experiments, which have developed the reflex of hopping aside when the wolf comes too close. Rabbits know this by being attuned to it. There is a mechanism for it, not necessarily one that involves a miniature map inside its head, but possibly so. The wolf and the rabbit both optimise their trajectories, if not as individuals, then as species.

Where the analogy between the inanimate and the animate may seem to falter is that the motions of planets are proportional to mass. A comet does not really budge a planet much, while a small dog can scare away a big bull. This difference shows that animate systems are open: agents are energy sources and have internal state. It is as if the conjunction of planets caused internal explosions on them which send them off course.

I move now to a qualitative description of the game of pursuit in terms of event types. The qualitative aspect of the differential equations into event calculus is translated by something like this.

Preferences:

- Romeo wants to be near Juliet. \( x \text{ want } x \text{ be near } y \)
- Juliet wants to be far from Romeo. \( y \text{ want } y \text{ be } \neg \text{near } x \)

Strategies:

- Romeo chases Juliet. \( x \text{ try } x \text{ become near } y \)
- Juliet avoids Romeo. \( y \text{ try } y \text{ become } \neg \text{near } x \)
On the assumption that Juliet and Romeo are free agents, we can solve the game by deriving the following play from the preferences and strategies:

When Romeo comes near Juliet, Juliet tries to go away from Romeo.

\[ \text{x be near y cause y try y become } \neg \text{near x} \]

When Juliet goes away from Romeo, Romeo tries to come near Juliet.

\[ \text{y be } \neg \text{near x cause x try x become } \neg \text{near x} \]

What we can’t prove one way or the other without more data is whether Romeo catches Juliet.

**Agency**

What is action, agency and agentivity in this framework? I propose to characterise agentivity in terms of reflexivity, going back here to Greek natural philosophers (Ar. Phys. VIII.4-5, De anima I, Shibatani 1976, Talmy 1976, 1985, 2000, Frawley 1992:163). The idea ties up with both the philosophy and grammar of action. By this view, an agent is a *primus motor*, or *first cause*, one whose activity is not caused by anything else, i.e. it causes its own action. This would make action by self, or *reflexive causation*, a distinguishing feature of agency (*autocausative* in Genusiene 1987:36).

Suppose we adopt this idea and analyse the agentive action as a *reflexive* action of John on himself causing his external action on the hammer, i.e John causes the action *by himself*. The outcome is that agentivity is defined by the following instantiation of the causation schema called the *do* schema *x do p*:

\[ \text{x do p : x cause x cause p} \]

(This makes *do* an instance of combinatory logic operator *S*.) *do* has an explicit definition as *cause self cause*.

What would the relevant reflexive action of John on himself be? When John is acting as a rational agent, it is, obviously, *reflexion*: an agent forms an *image*, a *plan* in his *mind* of the action to be carried out before carrying it out. The plan is in fact a cause of the action (Sellars 1973, Tuomela 1975). In that case the above definition can be further specified as

\[ (\text{x plan x cause p}) \text{ cause (x cause p)} \]

This is the case when everything goes according to plan: the even is intended and voluntary. There are cases where an event is caused by a plan but is not part of the plan, so that the *p* inside the plan causes another regrettable, indifferent or unforeseen event *q*.

Agency goes with responsibility, which presupposes control and intention. Control is two-way ability, Aristotle’s *potentia oppositorum*: the agent can choose whether the event happens or not. Agents are responsible for actions because they do them freely, *by themselves* (DeLancey 1984:193, Keenan 1984, Frawley 1992:205), no one or nothing *makes* them do them. On the other hand, agency involves *intended*, planned action, one which an animate agent had in mind before it happened. In other words, the agentive cause would be something of the order of *John want john hammer metal* or perhaps *john plan john hammer metal*.

Sometimes the condition may be weaker, the *dual* of wanting (acceptance, acquiescence) or planning (neglect, lack of forethought, not planning against the event happening). Such a weaker condition does not require mental effort – demonstrated *absence* of such activity where it should have occurred can be enough to get a conviction.

My approach differs here from Jackendoff (1987, 1990) in that it subsume agency as a special case of causation system instead of a separate tier. This treatment of agency has the advantage that it lines up agency with the rest of the hierarchy of semantic roles. Agent and object are roles in *do*, which both includes and is a specialisation of *cause*, which is includes and is a specialisation of *go*, which includes and is a specialisation of *become*, which includes and is a specialisation of *be*.

Mapping the causal roles onto the causal chain

\[ \text{john cause john cause hammer cause metal become flat} \]


Some of these roles and the corresponding cases might be defined as follows. These are object domain counterparts of the event roles earlier. For instance, the only difference between means and instrument (if any) is that an instrument is an object.

\[ \text{obj x: < cause x be|come <} \quad \text{acc < cause x be|come <: x} \]
\[ \text{agt x: x cause x cause<} \quad \text{erg x cause x cause <: x} \]

---

188Greek cognate verbs *boulomai* ‘want’ and *bouleuomai* ‘plan’ are both reflexive (medial).
These formulas make accusative a specialisation of a goal case, ergative a specialisation of a source, path, instrument, or comitative case, and oblique a specialisation of a goal case. Cross-linguistically, these predictions hold very well. Genitives, which primarily mark possession, may mark any of the above. Genitives get grammaticalised from all local cases.

Syntactically, cause is commonly inverted to an explanatory form because, which can be defined using combinators as

\[ q \text{ because } p = \text{inv} p \text{ cause } q \]

To complete Talmy’s (2000:415) fourfield of dynamic event types, we may add a definition of although or despite as the inverse of fail:

\[ q \text{ despite } p = \text{inv} p \text{ fail } q \]

where fail is defined as the Boolean difference try\-cause.

---

**Let**

Bennett (1988) considers the dual let of cause and notes it has agentive and nonagentive readings. The nonagentive let is \( p \noncause \neg q \), for instance, a door lets a person in if it is not locked. The agentive let is forbearance: \( I \text{ cause } I \noncause \neg q \), for instance, I let a person in if I decide not to stop him. People are held responsible for those events where the nonagentive sense is taken to entail the agentive sense: I am held responsible for letting something happen if I ought to have prevented it.

Talmy (2000:424, Jackendoff 19??) claim asymmetries between duals cause and let. Talmy stars

The plug let the oil flow from the tank.
I let the oil flow from the tank with the plug.

Is there an asymmetry here? Recall the definition of the instrument role in terms of cause.

\[ p \text{ cause } q \text{ cause } r \quad p \cap q \text{ cause } r \quad p \text{ cause } r \text{ with } q \]

By duality, let satisfies the same equivalences with let in place of cause, so there should be nothing wrong with the logic (Hansson 1971). For instance, the following are interchangeable. (We don’t expect with here because with instruments are inanimate.)

The Queen lets Parliament let men marry.
The Queen and Parliament let men marry.

What then is wrong with Talmy’s example? Not let, for let does allow instruments:

The barber let blood flow out with a knife.
Given determinism, cause is self-dual, i.e. cause equals let. When the barber lets blood with a knife, he is making the knife do something. And the blood not only wants out, it can’t help flowing out. It has no choice, no eadem potentia oppositorum. Thus the barber also makes the blood flood out. As predicted by this analysis,

I let the oil stay in the tank with the plug.
is odd, because the oil does not want to stay in the tank, it wants out. While again, the following two make better sense:

I made the oil stay in the tank with the plug.
I let the oil flow out from the tank with a siphon.

Remember also that agentivity provides a causal chain by my definition. Intransitive unergatives allow instruments.

The thief entered/let himself in with a key.

Therefore we always have to count with extra implicit causal operators when agentivity is present.

Lapolla/Van Valin (1997:308) make note of a sort of inverse of causative, the adversative construction My house burned on me / I had my house robbed by burglars with structure I let house burn cause I lose, where I am a goal of and adverse causal chain I could not prevent. Adversative or submissive voice based on grammaticalisation of let is one important type of diathesis (see section on voice). Adversative is a common ploy to avoid responsibility: fi En pudottanut sitä, se putosi minulta ‘I did not drop it, it dropped on me, it Mi si è perso il libro ‘The book got lost on me’, lv Vinam akmens iesviedas loga ‘A stone got thrown through the window by him’ (Genusiene 1987:275).
**Consequence and purpose**

The converse of a means clause is a consequence clause: the water ruins the floor by seeping under it iff the water seeps under the floor so as to ruin it (so that it ruins it, thereby ruining it). An imperfective paraphrase of a consequence clause is tend or threaten: the water threatens to ruin the floor when it seeps under the floor so as to ruin it (if nothing is done to prevent it it is likely to do so).

The inverse of an agentive means clause is a purpose clause: John (intentionally) flattens the metal by hammering it iff he hammers the metal in order to flatten it. The analysis just given explains why purpose clauses are nonfactual unlike consequence clauses. The analysis of *wolfs kill in order to eat* is

\[(\text{wolfs plan (wolfs kill let wolfs eat)}) \text{ cause wolfs kill}\]

in other words, the purpose of the killing is eating, the success of the plan is another matter. This analysis directly supports the paraphrase *Wolfs kill because they want to eat*. Purpose clauses pertain to the future because in the plan, the goal of the act follows the act. The tense is usually future, the mood subjunctive, and the case a goal case.

A paraphrase of a purpose clause is *try*: trying to do a thing is to do something in order to accomplish it (with the implicature that the outcome of the plan is not assured). Trying is intentional. What one does in trying may be completely off the mark: *I tried to flatter him but managed to insult him*. This shows that *manage* has a reading where it is a paraphrase of a consequence clause rather than a purpose clause.

The two paraphrases of a process accomplishment paint a picture ‘create a picture by painting’ and ‘paint to create a picture’ thus represent two ways to focus the same causal chain: paint:paint cause become picture and cause become picture:paint cause become picture, which correspond to the open (activity) and closed (change) interpretations of an accomplishment. The former invites durative adverbials, the latter bounding adverbials.

The syntax of a final (purposive) connective can be constricted using combinators as follows. Applying a suitable combinator \(X\), rewrite the prefix operator form of a final event type as an infix connective:

\[X \times \text{plan} (\text{cause} (p,q)) \text{ cause } p= p ((\text{because } \text{plan } p \text{ cause}) q)\]

The resulting composite infix operator (because \(X\) plan \(p\) cause) is a fair representation of in order that. Note that in this transform, \(q\) is inside the scope of \(\text{plan}\). This explains why purposive clauses tend to take subjunctive mood.

Notice another prediction of the above event type: the subject of the plan is a free variable. A sentence like

Our brother died so his brothers could be free.

does not necessarily describe my brother’s plan.

**Animacy**

Object types and role types are obviously dual. For an object type to be animate is equivalent to being a filler of animate roles like agent, experiencer or beneficiary (Chafe 1970, Genusiene 1987). Either can be defined in terms of the other. Etymologically, animate is an object type equipped with anima or soul.

For the *sensus communis* of the soul, see Aristotle, *De Anima*. Much more recently, cybernetics has sought for the soul in the machine in feedback, another reflexive notion (Ash 1959). In sum, it is reflexive causation of action by an internal state that makes up animacy. Conversely, reflexive pronouns are reputed to come from words for soul, head, body, or self (Genusiene 1987:303).

The difference between inanimate and animate is the system of internal states, anima. The more complex the internal states are, the higher one is in the animacy hierarchy.

What is the extra complexity? The thesis of this section is that animacy can be approached by enriching the model of reflexive causation above with a game-theoretical model of planned rational action (Carlson 1983, 1994).

Consider adjectives listed in typological studies of the animacy hierarchy. They include human, active, mobile, responsible. Why this list? The reason is that these adjectives denote already familiar roles. Being human entails, besides animacy, being a player of dialogue games, one of us. Active identifies a subject of do. Responsible identifies a subject of cause. Mobile means able to move (by itself), i.e subject of can and go.

The action of a rational agent is driven by images or representations. Plans are causes (Tuomela 1975). This is how in teleological causation, the future exerts a force on what is happening now. It is not the future that pulls events along, it is the mind’s image of it, the plan formed in an agent’s head, that pushes them from behind.

The difference between inanimate and animate causation is in the role internal state has in the explanation. Although a billiard ball prefers down - in a bowl it consistently tends toward the bottom of the bowl - it makes no plan to stay there, nor does it mind if something stops it from being there. Animates have thoughts, feelings, and freedom of will. These three are intimately connected.
Freedom of will means that action is not predictable (or predicted) without reference to the internal state of the agent. Future is branching if agents are subtracted from the equation. Rational action is again deterministic when optimal play is unique.

As Aristotle had it, an agent is free when he does what he wants. Strategies and utilities are dual. The more you want, the fewer ways there are to win. One is free when one can do what one wants. So either know more (Aristotle) or want less (Buddha).

The question whether the internal state is predictable in turn is not raised. The elusive concept of control is so elusive just because it is relative to how causal factors are sorted out in a given situation. A causal agent controls its actions if it is a prime mover: explanations of its actions stop at references to the internal state of the agent.

Thought is the ability to imagine the world as it is and as it might be. Thinking freely: not just replicating the environment, but (apparently) spontaneously generating alternatives to it, is the key to acting freely. This recalls Hintikka’s (1969) point about modality as multiplicity of reference: the actual world is treated as one among many alternatives.

Reactivity and movement are on Aristotle’s short list of life signs (Ar. De anima 403b). Both constitute communication with the environment, exchange of energy and information with it. A perception involves a propositional reaction to physical action. Emotion involves a physical reaction to propositional action. A billiard ball shows no feelings, we can explain its preferences without reference to its internals. A plant which shirks from touch it must feel something, but does not show enough internal state to have feelings ascribed to it. (Kenny 1963, Oatley/Johnson-Laird 1997, Lazarus 1991)

These explications are consistent with the analysis of the modalities of agency in Carlson (1994). An agent’s wants are beliefs concerning preferences and intentions are beliefs concerning plans. A rational agent is one who intends to do what he wants to do and believes he can do. They also agree with previous formal developments to the letter: an agent is free if ceteris paribus conditions entail that it does what it wants (and only that), i.e. it does something iff it wants to do it:

\[
\text{free: } \sigma \rightarrow x \text{ want } p \leftrightarrow x \text{ p}
\]

which precisely the previous causal explication of \(x \text{ do } p\)

Cognitive event types involve reception, acquisition, storing, and processing of representations. Their aspects behave accordingly. Perceptions and emotions are framed in languages as passive reception: see, be frightened. Direct object and propositional complement constructions differ in aspect: object constructions denote processes, complement constructions dispositions. I thought about it a lot, I thought it was ok. Many cognitive states acquisitions: believe, remember.

Communication in particular involves a sender, a recipient, and a message. The sender makes the message resemble what she has in mind and the recipient uses it to figure out what the sender meant. Communication is thus an instance of the object causation schema where the sender forms a message and passes it to the recipient. The sender is an agent and source, the message is a medium and instrument, and the recipient is a goal and patient. What distinguishes true communication from (other) message passing is that it is social action, a true game theoretical game based on mutual knowledge and expectations. Ability to play such games may provide the best characterisation of the object type human.

My explication of animacy in terms of event composition suggests a fresh approach to relating animacy hierarchy and diathesis. Study cases where diathesis is conditioned on animacy for structural differences between animate and inanimate roles. Many languages describe animate interaction as (two-way) communication (a game) rather than one-way causation. The net effect is that the second animate argument of the event type is not a direct object, but an indirect one.

Plank (1979:11) citing Finck (1907) finds evidence for two alternative clusterings of roles in subject selection: one by animacy pitting agent-experiencer-possessor vs. patient-stimulus-possession on the one hand (animate vs. inanimate), and one one by direction pitting agent-stimulus vs. patient-experiencer on the other hand (source vs. goal).

Want
Why do people want things? Want, etymologically, means be without. We want things we don't have.

Well, we don't want everything we don't have. What do we want? Apparently, living things want things that let life go on. By natural selection, those who got the things they wanted are the ones that survive wanting them. Animate want things that are good for them (in the average, in some environment); they want them the harder the better the things are for them and the harder they are to get (in a given environment). Selection goes wrong when organisms land in an

\[189\]Propositional means true or false. An image is true or false of an original under an interpretation (a morphism) according as the morphism exists between the image and the original.
environment where they easily get a lot of what used to be hard but good to get a little of. For similar reasons, people go wrong wanting things that are good in a short run but bad for them in the long run.

Accept, like, prefer, and want are related as not bad, good, better, and best. Across languages, the words are sometimes etymologically related accordingly.

One who wants something is attracted to it. If one is not at the goal, one strives toward it, if one is there, one is reluctant to relinquish it. A harder question: why is it good for things to come together rather than go apart (Lakoff 1983)? Well, life is a back flow, an eddy in the slow drift toward heat death. Life is about constructing complex things out of simpler ones in a universe which on the whole is bent on doing just the opposite. Life and growth is putting things together, death and destruction take them apart. Animates like us want good things to come to them (and to their friends) and bad things to go away from them (and to their enemies).

Ability

There are two elements to ability. It has a physical, component which involves power, having enough energy and mass, being strong and big enough to overcome opposing forces. Looking back at the game of pursuit, the constraints on players’ strategies: the power they are able to generate and the forces they can muster are mathematically related the energy they have got, proportional to their momentum (mass and velocity). Big players are strong, and so are fast ones. But ability also has an information component which translates into skill, knowledge what to do when in order to reach a goal. In the game of pursuit, this the dependence of Juliet’s strategy on Romeo’s. There is often a tradeoff between the two: a clever agent can get by with less force, a powerful one does not have to plan ahead.

Combining these two ideas forms a game theoretical characterisation of ability. Ability is having a winning strategy in a suitable game. A winning strategy is a strategy which guarantees a preferred outcome against any choice of strategies by other players. This is the power element. A strategy is a choice function, a rule which selects a subset out of a set of alternative outcomes at each of a number of choice situations (Carlson 1994, cf. Thomason and Gupta 1981). This is the skill element.

A strategy is a conditional plan, not just a single-minded push in one direction. Skill is varying response in reaction to different eventualities in a way which always sums up to the attainment of a goal. A strategy for going straight could read: I’ll try to go straight. If I make it, I just keep going. Whenever I veer left, I turn right, and whenever I veer right, I turn left, until I am on course again. In order for a player to have this strategy, he must know when the antecedents of the conditionals hold, i.e. he must see where he is going.

Such considerations suggest that the logic of ability is that of a dyadic regular (existential-universal) modality (Carlson 1994). The assertion of the existence of a winning strategy for a goal has just the requisite existence of the two outcomes at each of a number of choice situations (Carlson 1994). The assertion of the existence of a winning strategy for a goal has just the requisite existential-universal form: There is a strategy which for any combination of strategies of other players produces a given result:

$$\forall \sigma \exists \pi \quad \sigma \cap \pi \rightarrow r$$

If the game is a zero-sum game, the other player(s) will be opponent(s) whose goals are the complement of the player’s goals. We can in fact define a physical game of two opposed forces pushing or pulling opposite ways as a special case of a zero-sum game. The opposite goals correspond to the movement of an object in two opposite directions. The strategies are the forces impinging on the object. My having a winning strategy means that the resultant of the two forces moves the object my way. By a change of direction which the opponent is not able to react to I may be able to deflect an opponent’s force and win. Although the opponent has a stronger simple strategy, he has no strategy to counter a conditional one - he just keeps pushing the wrong way.

As a matter of logic, if x can do something e, then (in that same game) no one else, including x’s opponent, can do the opposite ¬e, for opposites define a zero-sum game. Either one player wins, or the other does, or it is a draw, in which case neither wins. It is possible for neither player to have a winning strategy, but impossible for both to win at once. It is also possible for the same player x to have winning strategies for both e and ¬e: then x has free choice between e and ¬e, i.e. x has control over e.

This eadem potestia principle is supposed to hold of moves in games is the: an agent can choose, or control, whether something happens or not. This holds for moves in simple games, but fails for events in general: some can be brought about, some prevented, most neither. With the practical syllogism, eadem potestia entails another form of determinism: a free agent causes whatever he does not prevent. Consider for instance:

Player A let player B win. A made B able to win.

If A has a winning strategy and B wins, these sentences seem to say one and the same thing. (We won’t say that A made B win as long as B has losing choices left). Let implies make able in simple games. This inference is a rational entailment rather than a logical one, in the sense of Carlson (1994).

Can we relate the physical sense of can of having requisite energy, mass or information to the strategy sense described above? We must, if the two senses of can are consistent. Strategies are channels for energy or information. Can means
there is a strategy which causes something. A moving object can hit another because it has momentum which gets converted to kinetic energy. If something comes in its way it will hit that something. It can move what it hits if it has enough momentum. It won't choose what it hits, it will hit anything in its way, so in that sense it has only one strategy. Can is a state in physical terms because it is a point integral wrt time, or, put in another way, because it converts events (power, flow, current) from time to space (energy, mass, charge, whatever).

More generally, to be able is to have means to do something. Wings and legs are means, what one flies and runs with. Wings fly, rather, wings let one fly. Legs run, legs let one run. One makes one's legs run, and then one's legs make one run. My legs are in a symmetrical causation relation with me, i.e. me and my legs are communicating automata. I win: I have many strategies, my legs only have one. (Unless they fail me. Sometimes they may appear to have a will of their own.)

Conditions that are necessary parts of sufficient conditions are things that allow one to do things. They are all moves in some strategy. That connects boundary conditions and differential equations. Differential equations are the universal or necessity part and boundary conditions are the existential or possibility part of an explanation. So one can do something if there are boundary conditions under which one by a natural law has to do something. One does something when the conditions hold.

Means let something happen, and when one makes them do it, then they make something happen, and make one do it. Strategies are means. On the other hand, means are also paths, or points on a path. They are on the way from here to ends.

Ability modals are different from weak modals in that they often strongly suggest success, especially in past tense or perfective aspect. He was able to come and Il put venir explain, hence implicate, a past fact. This is an unusual situation in modal logic. An axiom a posse ad esse tends to reduce modalities into determinism, making all that is possible also true and necessary. When is the inference a posse ad esse justified? Murphy's law is of this form: if anything can go wrong it does. It is a pessimist or paranoid view of a world basically out to get us. But a posse ad esse is also applied when an agent is free, i.e. able to do something he wants. This is a version of the practical syllogism: an agent who wants to do something and is able to do it does it. It represents the rational strategy of a player of a particularly simple game (Carlson 1994). Etymologically able comes from habilis 'having', can is related to know, and might is related to magnitude. Ability is to have potential or information. Having something is a state. A possession counts as an ability or inability depending on whether that is a good or a bad thing that one has. Not having a good thing means having a bad thing.

Knowledge

Reichenbach (1956) reduces knowledge to causation. One thing knows about another when the latter causes a change in the former. (Compare the causal theory of knowledge, Goldman 1967). Knowledge by contact (aka knowledge by acquaintance) is about past events because knowledge is an effect of a cause. This also explains why know is a passive or resultative event type. You don't do anything when you know, instead, you have been done unto.

Knowledge is veridical, what one knows is true, so knowledge is a morphism of events. Only nature is omniscient. Anybody else, as a proper part of what goes on, has only partial knowledge, a many-one morphism of events.

In game theory, past or present situations which remain indistinguishable for a player belong to an information set. The mapping from the set of game situations to a player's information set is a quotient map. There are no information sets in the future, because a player's strategy cannot depend on them anyway.

To know is to have information about something. Future is known by the past when the future is like the past. Subjected to the same cause often enough to adapt to it, an agent seeks to an optimum in its dealings with it. The memory of the past event causes a plan, a plan causes action (Tuomela 19??). Knowledge becomes power: the more information sets, the more strategies.

Knowledge about events allows regulation. A regulator knows the disturbance it regulates. Ashby's (1956) law of requisite variety says that a regulator's capacity at most equals its capacity as a channel of communication. In regulation, information increases and entropy decreases, so it takes an open system.

A game is an instance of regulation (Ashby 1956). At the equilibrium, information is at a maximum and entropy (uncertainty about the outcome) is at a minimum, because we can predict what everyone does. The physical problem of maximizing entropy and the game theoretic one of minimizing expected loss can be shown to be dual to each other (Grünewald/Dawid 2002).

A good regulator insulates an organism from the environment. It knows enough about the environment in for the insulated part to ignore it. In a game of pursuit, the position of the prey carries information about position of the predator, but prevents the goal of the predator from predicting the outcome. Pursuer controls the regulator of the prey, but not its vitals. (Isaacs 1965)

Strategies are regulators: they take out entropy from the outcome, improve information (prediction) between preferences and outcomes, and insulate game value from opponent strategy choices (disturbance).
**Knowledge and power**

In the section on games, it was pointed out that strategies and utilities are dual in game theory (one can balance strategy loss with utility gain). Imperfect information takes quotients of strategy sets, making the set smaller. Conversely, information increases strategies. Again knowledge is power.

To know is to maintain a morphism. A larger memory keeps more morphisms. If you know how to do something, you don't need so much energy: you can use the route of least resistance. You don't have to seek, waste energy on trial and error.

Brain and brawn are dual. A stronger player does not have to optimise either, he can barge through obstacles. The stronger player has more strategies too, for he can use the shortest path not available to a weaker one.

There is a physical interpretation of the duality of knowledge and power. Power resides on the up slope of an energy or entropy slide. Information is dual to potential: potential is uneven energy, information is uneven probability. Probability and potential are are brought together in Markov processes (Lyons/Peres 2002): The potential between two points is proportional to the probability that a random walk enters one before the other.

**Intention**

Intention or plan is choice. Will is deliberate want, all things considered. There can be an irrational element in it too, a choice among indifferent alternatives. In game theoretical terms, one intends things which follow from the strategy one chooses as the solution of a game (Carlson 1994). This may very well include things one would not want. What one will do is something one can do, which is usually less than what is possible, or would be possible if something else were not a fact.

One can wish those unwanted concomitants would not happen. A wish is a preference about something that is not in one’s power.

It has been pointed out that what we can do and what we want to do are not logically independent (Davidson 19??). A game draws conventional boundaries between what the strategies and what the goal of the game are. But a player may cheat or opt out of a game into a larger game and follow a strategy which he should not have by the rules. The decision to play along is also a solution of a game. There are a lot of things we say we can’t do when we just don’t want to do them. This is relativity in the space of games: the solution of one game can be the game tree of another.

Will is an expression of future in English, with a somewhat obsolete alternation with shall in the first person. The alternation makes sense against what was just said. Preferential Will expresses free choice. Deontic shall expresses forced choice, somebody else’s will. It is polite, and a better excuse, to express one’s own plan as an unwilled, imposed choice. In reality, there is only a technical difference between free choice and a self-imposed one. Intention is reflexive deontic modality.

The Indo-European Ursprache was supposed to have two nonindicative moods, a subjunctive and an optative (Krahe 1969: §43). The subjunctive was an expression for will and more generally conditional necessity (a strong modality), the optative one of wish and more generally conditional possibility (a weak modality). This is formally correct. Will is what follows from, is necessary given one’s plan. Wish is something compatible with, but only possible given one’s plan. One can will what one has a winning strategy for, the rest is subject to wish.

You may object that one can wish for things which can’t happen. True, but then the wish is expressed counterfactually. Compare I wish I shall win to I wish I had won.

**Animacy hierarchy**

Diathesis phenomena in natural languages attest to a hierarchy of roles in event types known as the animacy hierarchy (Dixon 1979, Bresnan 1987, Kiparsky 1987, Klaiman 1991,). The exact details of the roles in the hierarchy and their ordering varies from author to the next. Here I ask whether the event calculus can produce principled ways to resolve these questions.

My idea is to look for a basis of the hierarchy in the topology of definitions of event types. I conjecture that a role is the higher in the hierarchy the closer it is to the origin of the most important event type for humans, the role of myself, the deictic center I in a n-person game.

In terms of the tree of role definitions, the animacy hierarchy reflects a left-right top-down preorder traversal of roles in the tree. Height correlates with the complexity of the defining event type (number of internal states), precedence with control (freedom of choice).

Klaiman (1991:111) proposes the hierarchy agent > beneficiary > experiencer > patient > theme > location. This seems to accord with my idea quite well. I is highest, as it is leftmost and highest role in the event type of a game. Agent is a source and beneficiary a goal of a 2-person game. Experiencer is a goal in a 1-person game. Patient is a goal in a causative event type, which is higher in the tree than theme (subject of a change).
Elsewhere, I have emphasized that the network of role definitions in the event calculus has no unique axiomatics. This may be one reason why it has proved to be so difficult to come up with a fixed animacy hierarchy.

**Dynamics as a cartesian closed category**
Dynamic concepts produce commuting triples characteristic of cartesian closed categories:

<table>
<thead>
<tr>
<th>potential</th>
<th>gain/loss</th>
<th>velocity</th>
<th>acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \dot{f}dv )</td>
<td>( \dot{f}dv/dt )</td>
<td>( v )</td>
<td>( dv/dt )</td>
</tr>
<tr>
<td>energy</td>
<td>power</td>
<td>impulse/momentum</td>
<td>force</td>
</tr>
<tr>
<td>state</td>
<td>process</td>
<td>cycle</td>
<td>change</td>
</tr>
<tr>
<td>strong</td>
<td>work</td>
<td>move</td>
<td>push</td>
</tr>
<tr>
<td>strategy</td>
<td>win</td>
<td>act</td>
<td>plan</td>
</tr>
<tr>
<td>can</td>
<td>make</td>
<td>do</td>
<td>try</td>
</tr>
<tr>
<td>good</td>
<td>get</td>
<td>choose</td>
<td>want</td>
</tr>
</tbody>
</table>

Table 53
Energy causes effort, effort causes flow. (But also conversely.) Power (rate of accumulation or consumption) is involved in the semantics of notions like *lose/spend vs. gain/gather*. The former model the differentiation (expenditure, loss) of energy (stored in space) into power (expended in time), the latter the integration (accumulation, gain) of momentum (gathered in time) into energy (stored in space).

Cartesian triples yield familiar interrelationships, like the ones characteristic of the practical syllogism:

\[
\text{can} = \text{do if try, do} = \text{can and try, try} = \text{want and can, want} = \text{try if can.}
\]

Aristotle’s terms *dynamis* (potential) and *energeia* (activity) correspond to potential (energy) and (power) gain/loss, respectively. Activity realises potential in a time, potential sustains activity for a time.

The analogies have relevance to aspect. The aspect types of the concepts involved are predictable from their definitional relationships. Ability (potential, energy) is a state. An effort (force, acceleration) is a change (acceleration). Starting and stopping are changes between (relative) rest and motion. An object is given momentum by applying force for a time (impulse): a cycle. Activity (power, gain/loss) is use of energy per time: a process.

**Object causation**
We have construed *cause* so far as a relation of events along with Vendler (1967), Geis (1973), Dowty (1972) and McCawley (1976). Bennett (1988) proposes that object causation, event causation, and fact causation are descriptions of the same course of events of increasing specificity. *The cat and the dog caused the mess* is short for *The fight between the cat and the dog caused the mess* which is short for *That the dog chased the cat around the room caused the mess*.

This line of thought is compatible with mine. Since I identify objects with events, object causation *is* event causation for me. An event in an object’s history which specifically causes something the object causes is a subevent of that object, considered as a complex event. In analogy with the notation introduced for relation algebra, event calculus verifies the identities

\[
e = x \ p \ cause \ y \ q = x \ p \ cause \ e \ cause \ y \ q = x : x \ p \ cause \ y : y \ q
\]

This equation makes literal sense of *transitivity* as the idea that a transitive relation involves a causal flow from the subject to the object through the transitive event \( e \), and *object causation* as the idea that an *object* \( x \) as the subject of \( p \) is a cause of the event, and the *object* \( y \) of \( e \), become the subject of \( q \), is an effect.
Having events

To understand object causation, it is necessary to study what it means for participants to *have* events. There is a host of expressions that locate participants in events. There is the progressive: a participant is *in/at* an event when it is the subject of an (initial or medial open sub)event: *in flight, on the run, at work.*

By my analysis of *have,* to *have* an event is to be caused to be *at* or *with* an event, or, by inversion, the event to be *with* one. A symmetry follows from reflexivity: when one has an illness, one is in the illness and the illness is in one, i.e. one is *with* the illness. Thus we have a principle like

\[ x \ e = e \ be \ with \ x = x \ has \ e \]

What it means to have an event depends on the values of certain parameters: the tense and subject of the event, the cause and whose plan the event is. We have a fourfield:

<table>
<thead>
<tr>
<th>subject\tense</th>
<th>fut</th>
</tr>
</thead>
<tbody>
<tr>
<td>refl</td>
<td><em>I have done work</em></td>
</tr>
<tr>
<td>x have x work(&lt;</td>
<td>x have &lt; x work</td>
</tr>
<tr>
<td><em>I have work done</em></td>
<td><em>I have work to do</em></td>
</tr>
<tr>
<td>x have y work(&lt;</td>
<td>x have &lt; y work</td>
</tr>
</tbody>
</table>

Table 54

The relevance of tense is clear: to have a past event have \( e< \) is to have a result state \( e'\) \(< \) now, to have a future event \( < e \) is to have a plan or preparatory activity \( <'e \) now. The relevance of reflexivity is equally clear: to be the subject of an event you have means you do it, else someone else may do it. On the reflexive reading, *I have work to do* comes close to *I have to do work.*

The cause of possession makes a difference. Unpacking *have* we get *z cause x be with < y work.* If \( z = y = x \), we get an intention. If \( z = y \neq x \), we get a factitive, either commissive or adversative, depending on preferences. Someone is having someone else work, either for them or against their will. The adversative reading is more salient with the past tense, since adverse events are not planned: There is *I had my car stolen,* but there is also *I have nothing to lose.*

With \( z \neq y = x \) we have an obligation: someone else is causing \( x \) to work. Preferences make a difference here. Take *I have work to do,* the plan does not agree with \( x \), we i.e. \( x \) must work. If \( x \) prefers to work, we get an abilitative reading: someone is letting \( x \) work, i.e. \( x \) is given work. It is striking how systematically entailments fall out from different settings of parameters on this analysis of *have.*

Property passing

Ballistic causation, or *property passing,* is subject-predicate inversion applied to object causation. It elaborates the idea (also visible in the term *transitive*) that causation involves the *transition,* or passing of something, a message, impulse, particle, or whatnot, from cause to effect (Langacker 1987, 1990:229). It applies the classical Greek analysis of change as motion of properties (*kinesis*) to causal events.

Looking at the causal chain from this angle, you can see it as the passage of a change from John all the way to the metal. The change starts out in John’s head and is passed through intermediaries to the the object. John ‘had’ the impulse, he ‘put it in motion’ and it was ‘passed on’ until it ‘reached its goal’.

This image is used in current physical models of causation. It has the advantage of explaining why cause must precede effect (the message or impulse takes time to travel from the cause to the effect). Note that the grammar term *reflexive* also fits the image: an impulse is reflected back to the sender.

This model of causation is obtained from event causation by subject-predicate inversion. From

\((x \ have \ c)\ cause \ (y \ have \ e)\)

we get with a Platonic subject-predicate inversion

\((c \ is \ with \ x) \ cause \ (e \ is \ with \ y)\)

Identifying the cause \( c \) with the effect \( e \) under some description or other, we can construe this as an instance of the motion schema *go:* some abstract property \( p \) which appears as \( c \) with \( x \) and as \( e \) with \( y \) passes from the possession of \( x \) to that of \( y \).

Let us have a closer look at this. Using subject-predicate inversion and setting \( p = c cause \ e,\)
x c cause y e
becomes (modulo counterfactuality)

\[ p \text{ at } x \leq p \text{ at } y \]

which says that the subject x confers, passes, or gives p to y. If, in particular, c and e are mutually exclusive, we can say that p goes from x to y. For instance, when a billiard ball hits another, it passes momentum p to another: first it moves (px) and the other one does not (¬py), then it does not move (¬px) and the other one does (py). The moving ball gives its momentum to the second in the elastic collision, by the law of conservation of momentum. The event type move literally passes here from x to y:

\[ \text{move at } x \leq \text{move at } y \]

equals (modulo counterfactuality)

\[ x \text{ move cause } y \text{ move.} \]

Property passing contains the idea that causation implies contiguity or a principle of action by contact: the shared change traces a continuous spatiotemporal path from cause to effect. Causation is an exchange of something. (Talmy 1976, 1985, Frawley 1992:162, Reichenbach 1956:189-202). Contiguity is one difference between kill and cause to die (Fodor 19??). Transitive verbs are said to involve manipulative causation, where the agent is in contact with the object.

In terms of property passing the agent is a source, the instrument is a path, and the object is a goal. We give properties to other things and receive properties from them.\textsuperscript{190} We can define x cause q by p as shorthand for x p cause q. Leaving out by p leaves p implicit (existentially quantified).

Object causation explains the case frames of verbs of creation and destruction and makes sense of the causative uses of change of possession verbs bring, give, and get. The object causative make is a variant of cause become:

\[ x \text{ cause } y \text{ become } z \]
\[ x \text{ cause } y \text{ come into being} \]
\[ x \text{ cause } y \text{ come about} \]
\[ x \text{ bring } y \text{ to } z \]
\[ x \text{ bring } y \text{ about} \]
\[ x \text{ make } z \]
\[ x \text{ make } y \text{ } z \]
\[ x \text{ make } y \text{ to } z \]
\[ x \text{ make } y \text{ into } z \]
\[ x \text{ make } z \text{ from } y \]
\[ x \text{ make } z \text{ out of } y \]
\[ x \text{ make } w \text{ into } z \text{ from } y \]
\[ x \text{ get } y \text{ to } z \]
\[ x \text{ give } y \text{ to } z \]

**Event passing**

We can now review a prototypical object causation in more detail. Take Al gave a push to Bill. This is a perfective variant of Al pushed Bill. The closure comes from the singular count article of a push which converts push cross-categorically to pf push. Another thing we must capture is that Al does the pushing and Bill is who gets pushed. This follows from the properter hoc principle: the cause precedes effect, so when an impulse goes from one object to another, the former is the cause and the latter the object. Looking at the pushing event as a temporal trajectory, its beginning is with Al and its end with Bill. Which is tantamount to saying that the Al is the source and Bill the goal of the push.

We also need to consider what it means for an event to go from an object to another. If the objects are flesh and blood and action is by contact, something or other is bound to go from one to the other quite concretely: say a fist, stone, or bullet. Viewing the fist as a four-dimensional object, an event in fact, we can see it trace a trajectory between the source and the target of the blow. In fact, the blowing fist and the blow of the fist define one and the same four-dimensional region; the difference is only one of perspective. The fist moves, because we view every temporal cross section of it as the entire fist at different times. The blow does not move (Dretske 1967), it goes from one time and place to another rather like a road goes between places.

\textsuperscript{190}This perspective shift is an example of subject-predicate inversion. Such a dual way of relating individuals and properties was the rule in Aristotle and other Greek philosophers, who took movement to be a more basic concept than change. Qualitative change was the movement of properties in and out of individuals. More recently, subject-predicate (lambda) conversion has been used in the theory of generalised quantifiers to replace individual constants with sets of properties.
The blow goes from the subject to the object, in that the roles played by the two participants in the event follow one another in time, and are causally related in the same order: first the owner of the fist acts, then, as a result, the target of the blow reacts. The subevent of giving the blow causes and is followed by the subevent of receiving it. For the blow to go from subject and object means none else than that the action of the subject causes the reaction in the object.

Given these assumptions, the object causation schema reduces to a causal chain of events in a few steps.

\[
\text{push go from a to b} \\
x:x \text{ push} < \text{ with a cause } y: < \text{ push y be with b} \\
a \text{ push} < \text{ cause} < \text{ push b} \\
a \text{ push b}
\]

The merger of the two subevents back into one event on the last line is licensed by the initial premise.

**Give and take**

Through object causation, give and get, the causative and passive of change of possession, become central cross-linguistic diathesis operators (Rangkupan 1997).

\[
give: \ x \text{ cause } z \text{ go from } x \text{ to } y = \ x \text{ cause } (z \text{ be with } x\backslash y) \ . \ (z \text{ be with } y\backslash x)
\]

In my analysis, give is causative of transfer of possession from subject to recipient, i.e. a possessive reading of \(x \text{ cause } z \text{ go from } x \text{ to } y\). In my analysis, one cannot give what one hasn’t got. It also entails that the object given goes away from the giver to the recipient: to give is to give away, to lose something. One who gives something has less. This is important for understanding the game of give and take, one of the central games for social animals.

Give (more) often denotes abilitation let, the dual of necessitation cause: (The difference need not materialise: in a deterministic situation, cause is self-dual.) To let something happen is to give in: fail to prevent it from not happening, formalized as

\[
c \sim \text{cause } \sim e
\]

When this is written out, let/enable is seen to be a weak (possibility-type) modality. The group of abilitatives includes also (senses of) allow, drop, leave, let, leak, permit. English does not have a causative from sleep, but does have an abilitative sense in The room sleeps two. Tagalog causatives are systematically ambiguous between necessitative and abilitative senses make/let (McFarland 1976:21). Notice that the equivalence of give and let have can be proved from my definitions.

Assuming the recipient is a player, we can consider the game of give and take as a two-player game. Since giving is voluntary, the agent must prefer the result state to the initial state. What the recipient prefers depends on whether the game is cooperative or competitive. In a cooperative game of giving, the unmarked case for sure, the players have the same utilities, so the recipient wants the gift. In a competitive game, the utilities are opposite, so the recipient prefers the initial state. Giving a blow belongs to a competitive game, where give gets and adversative sense.

Utilities in the game of give and take explain the duality of cause and let in the event type for give. What one wants is what holds in all preferred plays. Optimal plays are the most preferred plays accessible to a player. What one can do is what holds in some optimal play, and what one must do is what happens in all optimal plays. When one is allowed to do something, some preferred play is made accessible. When one is made to do something, all preferred plays are made inaccessible. Consequently, agents are allowed to do what they want, and made to do what they don’t want.

The unmarked utilities of the game of give and take also match the default deixis of give: the gift, benefit or utility, goes away from the giver and comes to the recipient. The converse verb take, inversely, is by default a hostile action, on the same supposition that what is taken is preferred by both players. It is easy to show that take = \~give.

\[
take: \ x \text{ cause } z \text{ go from } y \text{ to } x
\]

These defaults are easily reversed when the utilities of the game are different (one can take advice, responsibility, bribes etc). Note that this analysis makes take inherently medial (reflexive).

The event type for give also explains how come give oneself can come to mean go, as it does in Lithuanian, German and Swedish (Genusien 1987:147), or surrender, as it means in English, French, Swedish and Finnish (think of the etymology of surrender itself, for that matter).

**Dative**

The thematic role of beneficiary, the classical dativus commodi, can be defined as a goal (or recipient, i.e. goal of possession) if a purpose clause. It immediately follows that a beneficiary entails an agent. A clue to the logic of beneficiary is the following contrast:
Nuan buys/sells clothes for her kid.

With *buys*, the kid gets the clothes, with *sells* he gets the money. In each case, the beneficiary gets something from the subject. The subject does the work and the beneficiary gets the benefit.

\[ \text{Nuan plan (Nuan buy clothes cause Nuan give clothes to kid) cause Nuan buy clothes} \]

\[ \text{Nuan plan (Nuan sell clothes cause Nuan give money to kid) cause Nuan sell clothes} \]

This analysis of beneficiary correctly predicts a few things. For one thing, beneficiary entails an animate subject frame, because planning is involved. Second, it entails a transaction from the subject to the beneficiary: doing something for someone is a form of giving. Thus beneficiary role is \( y \) in the event type

\[ x \text{ plan} (x \text{ p cause z go from } x \text{ to } y) \text{ cause } x \text{ p} \]

For instance *Nuan dies for her kid* will be represented as

\[ \text{Nuan plan (Nuan die cause Nuan give z to kid) cause Nuan die} \]

Nuan gives her life to the kid. What the kid gets in return for it is not specified in the definition. It could be the kid’s life, but it could be something else. The analysis of beneficiary in terms of giving will come to use in the section on Thai. Matching the definition of beneficiary to the event type for *buy*, we can also infer that Nuan buys something for the kid with her life.

To complete the picture on beneficiary role, we need to study the event type of *give*. In my analysis, *give* is causative of transfer of possession from subject to recipient, i.e. \( x \text{ cause z go from } x \text{ to } y \). One cannot give what one hasn’t got. Also, this event type does not make the subject animate, for instance an attempt can give (yield) a result without meaning to. To build in animacy into *give* it suffices to replace *cause* with *do* so as to get

\[ (x \text{ plan } x \text{ cause } z \text{ go from } x \text{ to } y) \text{ cause } z \text{ go from } x \text{ to } y \]

Does the beneficiary have to be animate? More to the point, it must be something a benefit can be ascribed to. One can die for a cause.

In a competitive game of give and take, the players have the same utilities, so the recipient wants the gift. In a competitive game, the utilities are opposite, so the recipient prefers the initial state. Both types seem to occur for the beneficiary role: Jesus died for us, while the devil has evil designs for us.

There is a fine difference. *For* allows two senses in *Nuan washes clothes for her kid*. (Rangkupan 1997, Van Valin/La Polla 1997). Perhaps the clothes go to the child. Or perhaps she just does the washing for him, either in his place or to his benefit some wider sense. Translations of *for her kid* in Finnish differ accordingly: *lapselleen* ‘to/for’ against *lapsensa puolesta/hyväksi* ‘in behalf/to the benefit of’. These senses are called recipient and “deputative” beneficiary in Van Valin/La Polla.

The two senses can be associated with two attachments of *for*, either to the object *clothes* or to the verb phrase *wash clothes*. Only the latter sense is available for intransitive *Nuan dies for her kid*. Now it seems that an adversative meaning is available only when there is an adverse object available for the former attachment. When there is none, or the attachment is high, *for* has a beneficiary reading while *against* is needed for an adversative one.

\[ \text{Davy is mixing poison for the dingoes / aborigines.} \]

\[ \text{Davy is building a fence / shed / fighting for his sheep / against dingoes.} \]

How to explain this difference? One way to do so is to consider what the \( z \) is that the beneficiary gets. In the low attachment, the beneficiary \( z \) is the object. Whether it is to their advantage depends on the gift.

In the high attachment case, \( z \) is the utility or outcome of the plan for the subject. Since the subject wants it and wants the beneficiary to have it, the game must be cooperative. Conversely, given a cooperative game, entailments about the subject’s and the recipient’s preferences in the game fall out without separate stipulation.

*For* is etymologically related to *before*. Note that the beneficiary event type is related to the animate factitive event type

\[ \text{The kid gets Nuan to wash the clothes for him.} \]

The causal chain explains in what sense it is that Nuan washes the clothes (*be*)for(e) or instead of the kid. The causal chain is driven by the kid’s preferences though executed by Nuan. Just like the factitive, the benefactor stands between the source and goal of the plan. The main difference to the factitive is whose plan is involved, Nuan’s or the kid’s.

This insight can be formalised as follows. A factitive is an event type where there is a plan for a deal, a give and take between two agents. The principal plans that by giving something to the undertaker he can induce them to do something for him:

\[ y \text{ plan} (y \text{ p cause y give z to x cause x plan} (x \text{ q cause x give w to y}) \text{ cause } x \text{ q}) \]

Suppressing detail, this event type entails the benefactive event type.
The syntax of a beneficiary adjunct involves combinatorial transformations of

\[ y \text{ plan } p \text{ cause } y \text{ give } z \text{ to } x ) \text{ cause } p \]

One way to pack the information is to to invert the cause and effect and rearrange the rest to

\[ p \text{ (because } y \text{ plan } p \text{ cause } y \text{ give } z \text{) to } x \]

which produces a goal adjunct with a complex semantics. Another way is and apply serial verb composition, leaving just the verb give on the surface.

\[ p \text{ (because } y \text{ plan } p \text{ cause } y \text{) give (z to) x} \]

There is an interesting difference between Russian or Lithuanian dative and Finnish allative shown in examples like

Ona shukuaja vaikui plaukus. ’Ann is combing the child’s hair’. **comb hair go to child**
Anna kampaa lasta / lapselle jakausta (?tukkaa). ’Ann is combing the child / ?hair / a parting to the child. **parting go to child**

Lithuanian dative case can mark the recipient of an event type, while the Finnish allative can only mark the recipient of an object. Object *tukkaa* ‘hair’ would oddly suggest that the combing gives hair to the child. Note that Finnish does not use dative with verbs like *help* or *follow* either, but partitive.

**Help and follow**

Game event types having to do with doing things *to, for or with someone or together* is a source for indirect object event types which get special treatment across languages. Two agents are involved, with give and take between them, working on a common object. The agent is a source or goal but not an object: they win or lose something but do not change.

The beneficiary role is related to the semantics of the verb *help*. For an agent to help others is (among other things) to do things for them in order to let them accomplish something:

\[ x \text{ help } y \text{ to } p: \quad x q \text{ because } x \text{ plan } x q \text{ let } y p \]

This semantics lets one help without being of any help. It is the good will that counts. Little children often help their parents in this way. The implication that \( y \) is a beneficiary follows from the game dynamics of letting and giving.

The plan for helping in the above event type is an instance of event type \( y \text{ cause } p \) with \( x \) which in turn is equivalent to \( x \) and \( y \) cause \( p \).

\[ x \text{ help } y \text{ to cause } p = x \text{ and } y \text{ cause } p = x \text{ cause } y \text{ with } p \]

This shows that the help event type is underlyingly symmetric. There is a difference of perspective and responsibility: who stands to gain from the event is the primus motor or unmoved mover in it. This is the sense of *help* relevant for the English modal *can’t help*. What it means is that one can’t *help oneself against* something, one can’t but bring it about:

\[ \neg \text{ may (} I \cup I \text{) cause } \neg p = \text{ must (} I \cap I \text{) let } p = \text{ must } I \text{ let } p \]

A related inherently dative event type is *follow*:

\[ x \text{ follow } y \text{ to } p: x \text{ go to } p \text{ because } y \text{ go to } p \]

This can similarly be proved equivalent to \( x \text{ go to } p \) with \( y \) and \( x \) and \( y \text{ go to } p \). Thus it is equivalent, modulo animacy, to \( y \text{ go to } p \) with \( y \) and \( y \text{ go to } p \) cause \( x \text{ go to } p \), which is the event type of *take along or bring*.

**Communication**

The verbs *send* and *receive* are at the heart of a theory of *communication* (Shannon 1949). This term, taken liberally, comprises not only human conversation, but also more primitive animate instances of message passing, such as emotion and perception, up to and including plainly inanimate and mechanical information transfer.

Giving and getting can happen (it prototypically does) in immediate contact, as when a gift changes hands. Sending and receiving *must* have a separate medium, which implicates a longer distance and uncertain reception. Thus the event type of send and receive is minimally.

\[ x \text{ cause } y \text{ go from } x \text{ to } z \text{ in } \neg(x \cup y \cup z) \]

This rules out for instance that \( x \) hands or *takes/brings* \( y \) to \( z \). Everyday instances of *send* and *receive* are *throw* and *catch*. Throwing is (roughly) letting an object fly free by giving it a swing with an arm.
In communication, there is a *channel* between sender and receiver. The channel is a path. It is long and narrow compared to the sender and receiver, i.e. the *capacity* of the channel is less than that of the endpoints. Messages must be *encoded* and *decoded* to fit the channel, so they take time to travel from one end to the other. There is *noise* in the channel, so what one sends need not be what the other receives. This causes errors in reception (perception).\(^{191}\)

The event type of *say* as a verb of communication might include

\[(x \text{ plan } p \text{ go from } x \text{ to } y \text{ in } u) \text{ cause } (x \text{ cause } q \text{ go from } x \text{ to } z \text{ in } w)\]

where \(x\) is speaker, \(p\) and \(q\) are messages, \(u, w\) are encodings or channels, \(y\) is the addressee and \(z\) is an audience. (Wierzbicka 1987). On this analysis, addressee is the intended goal of the act, not necessarily the actual one.

It is not difficult to infer event types on the above list from this type or one of its equivalents:

- **agentive**: \(x \text{ plan } x \ p \text{ cause } x \ p\)
- **causative**: \(p \text{ cause } q\)
- **motion**: \(p \text{ go from } x \text{ to } y\)
- **propositional object**: \(p \text{ be } q\)

A perception verb like *see*, to take another example, might be represented as a two-way causation along the following lines (Croft 2001):

\[(x \text{ cause } gaze \text{ of } x \text{ go to } y) \text{ let } (y \text{ cause } image \text{ of } y \text{ go to } x)\]

The activity of looking allows the object to impinge on the experiencer. The object causes the perception, but the subject enables it by looking in the right direction. Because of the two-way causation, both experiencer and cause have a multitude of roles for languages to focus on.

*Emotion*, as the name says, is bodily (com)motion caused by mission critical information. This is the gist of the so called cognitive theory of emotion. One *is moved* by messages from or about *good and bad* events. As with (other) perception, reception has a passive success sense (*scare*) and an active conative one (*fear*). See also sections on perception and animacy.

This analysis explains why emotions are universally couched passively as emotion causative constructions. It also explains the array of roles which go with emotions. Emotions have factual causes, fictive targets, and propositional content (*from/at/that*).

**Light verbs**

The very same event types recur across languages as auxiliary verbs, light verbs, or support verbs. From a category theoretic point of view, they can be recognised as initial objects of closely related basic categories of events. This section studies symmetry groups formed by these verbs; including *be, have, become, come, go, get, give, take, cause, let, make, can, must, control, happen, want, know*, and others. The list is not closed, for event types can be stepwise refined.

Symmetries fall out from given characterisations of these event types. The top event types commute in small and tight circles.

\[
\begin{array}{ll}
I \ p = I \ be \ at \ p & I \cap p > \emptyset = I \subseteq x : x \cap p \\
I \ have \ x = (not? \ I) \ cause \ x \ be \ at \ I & I \ atomic \ relative \ to \ p \\
converses & have = \sim \ be \ at \\
I \ become \ p = (I \ be \ not \ p \ . \ I \ be \ p) & I \ get \ x = I \ take \ x = (not? \ I) \ cause \ (x \ be \ at \ not \ I \ . \ x \ be \ at \ I) \\
x \ come = (x \ be \ at \ not \ I \ . \ x \ be \ at \ I) & I \ give \ x = (not? \ I) \ cause \ (x \ be \ at \ I \ . \ x \ be \ at \ not \ I) \\
x \ go = (x \ be \ at \ I \ . \ x \ be \ at \ not \ I) & I \ take \ x \ to \ y = I \ get \ x \ to \ y = I \ cause \ (x \ be \ at \ not \ y \ . \ x \ be \ at \ I \ . \ x \ be \ at \ y) \\
I \ get \ x = I \ take \ x = (not? \ I) \ cause \ (x \ be \ at \ not \ I \ . \ x \ be \ at \ I) & x \ follow \ I \ to \ y = I \ take \ x \ to \ y \\
I \ give \ x = (not? \ I) \ cause \ (x \ be \ at \ I \ . \ x \ be \ at \ not \ I) & y \ bring \ x \ to \ I = y \ cause \ (x \ be \ at \ not \ I \ . \ x \ be \ at \ y \ . \ x \ be \ at \ I) \\
I \ take \ x \ to \ y = I \ get \ x \ to \ y = I \ cause \ (x \ be \ at \ not \ y \ . \ x \ be \ at \ I \ . \ x \ be \ at \ y) & I \ make \ x = I \ bring \ x \ to \ be = I \ cause \ x \ to \ be \\
I \ make \ x = I \ bring \ x \ to \ be = I \ cause \ x \ to \ be & I \ cause \ x \ p = I \ make \ x \ to \ p = I \ get \ x \ to \ p = I \ give \ p \ to \ x \\
I \ cause \ I \ cause \ p = I \ do \ p & I \ cause \ I \ cause \ p = I \ carry \ out \ p \\
\end{array}
\]

\(^{191}\) *receive* and *perceive* come from Latin *capere* ‘take, catch, get’.
I let x p = (not? I) cause not (I cause x not p) = (not? I) cause x p
I may p = (not? I) let I p
I can I cause p = (not? I) let I cause p
I control x = I master x = x obey I = x follow I = x do← want I
I win p = (not I) lose p = I control p
I can p and I can (not p) = I control p = I choose (p or not p) =
you depend on I = I free and you not free in (I and you)
I want p = I must p = I have to p = not I have p = I need p
I cannot help p = not I make p = not I give p to I = not I choose p = not I want p

Have is vague about what causes it. By logic alone, e equals 1 cause e, so (I U not I) cause e always holds. This is all that can be said about mutual things like quarrels: it takes two to have one. In other cases, the cause is attributable to one or the other, compare have a drink to have a blow. There is a clear correlation to what one wants.

A point worth noting is that come and get are inherently reflexive. I get what comes to me, and I come where I get. I get out means I come out. You get out means you go out. These equivalences are obtained by plugging I in place of x in the event types of come and get and interpreting I be at I as being where I want to be, i.e the goal of the motion.

I come = (I be at (not x: I be at x at u) at t), (I be at (x: I be at x at u) at u)
This says all about I come. But note it also says that I give myself to me! I go is a mirror image:
I go = (I be at (x: I be at x at t) at t), (I be at (not x: I be at x at t) at u)
What this says is that I give myself away. This is a way of saying leave in many languages (e.g. Swedish ge sig iväg).

More symmetries: Come and go is visit or pop in, go and come is pop out, give and take is lend/loan, take and give is borrow.

Get is vague between reflexive take and passive be given. It is reflexive in get drunk. This explains how come English has so few reflexive verbs (Genusiene 1987:§3): English replaces reflexives with "active" reflexive passives like get drunk. To get to be some way is to become that way, and to come to that condition. All of these equations are in place already.

Give is equally vague between giving freely and against one's will. Compare give a tip to give a cry. Get and take are near synonyms, different only by the default attribution of cause. But take too varies between active rip off and passive receive. The two place sense of take 'adopt' is obtained from the three place sense 'convey' by identifying source and goal arguments. Bring relates to take as come to go. Follow is a converse of take, with a slight difference to the preferred cause.

Cause is an abstract verb for event causation. Object causation variants get, make and bring are interdefinable with it as indicated. Force entails some opposition. Observe how the infinitival to retains its etymological meaning as a goal case here. Bring about is fully compositional too, about meaning about 1, i.e. somewhere. Just like the others, cause itself is vague between a reflexive agentive sense and an inanimate instrumental or "blind" cause. Carry out iconically conveys that an instrument is a vehicle for a higher cause.

The dual let of cause is also vague between empowered, willing permit and an unwilling failure give in. The duality repeats itself one level higher between free factitive I let you help me and forced adversative I let you hurt me.

What I can do is what Nature (the rest of the world) lets me bring about. I can do what I know how to do. What I can’t help (can’t prevent) is what I must, or have to do, in the forced sense of have.

Control is freedom, or two-way ability. To be free is freedom of choice: one can choose. To choose is to take to oneself. If I am free, I choose what I want. What I want is what I do not have and need. Under freedom, an agent is in charge of everything, under determinism, nothing. Under both forms of bivalence, dualities degenerate to let = cause, so let them die means make them die.

Support verbs
Support verb constructions are verb plus event object constructions where the support verb shares subject with the event and only changes the aspect of the event. English uses them a lot. Tabulating some of the possibilities, giving yes for both active and passive support verb readings and no for neither, we get

| look | try | thought | walk | mistake | gesture |
Table 55

<table>
<thead>
<tr>
<th>Verb</th>
<th>Yes</th>
<th>Act</th>
<th>Pass</th>
<th>Act</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>have</td>
<td>yes</td>
<td>act</td>
<td>pass</td>
<td>act</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>get</td>
<td>pass</td>
<td>pass</td>
<td>pass</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>give</td>
<td>act</td>
<td>act</td>
<td>act</td>
<td>no</td>
<td>no</td>
<td>act</td>
</tr>
<tr>
<td>take</td>
<td>act</td>
<td>?</td>
<td>act</td>
<td>no</td>
<td>act</td>
<td>no</td>
</tr>
<tr>
<td>make</td>
<td>yes</td>
<td>act</td>
<td>no</td>
<td>act</td>
<td>act</td>
<td>act</td>
</tr>
</tbody>
</table>

Not all grammatical uses involve a support verb, like give a drink, make a bath. These also have compositional meanings: giving a drink or making a bath need not entail that somebody drinks or bathes. The look class with the most positives allows both intransitive (passive) and transitive (causative) uses (e.g. take a blow from/at someone).

The table shows that support verbs share roles with the event. As their event types show, make adds a cause, take a cause and goal, give a cause and source, have and get a subject and goal. The difference between have and get is aspectual: have can be open or half closed, get is half closed. The difference between take and make is that take affects its object (nonresultative), make affects it (resultative).

Looking at the event types which take have/take: have a bath, drink, walk, thought, look, fall, it appears that they are reflexive (medial): the subject is also a goal of the event type. The subject of these event types is animate, not surprisingly given my analysis of animacy below.

**Event type automata**

By the duality of regular expressions and automata, event types can also be represented as finite state automata. Particularly interesting here are unbounded event types which contain repetitions, iterations or loops. If the repeat until analysis of causative accomplishments is right, this class includes a large share of natural language event types. The general scheme is this: to manage to do something is to try doing it until success:

\[ x \text{ do } p = x \text{ try } p \text{ until } x \text{ do } p \]

Thus the aspectual causatives try and manage effect a decomposition of any accomplishment into a preparatory process and a final change, where the preparatory process causes the change.

**Deadlock**

Another interesting looping event type is wait. To wait for something (to happen) or someone (to do something) means to do nothing (or not to do something) until the other thing happens:

\[ x \text{ wait for } y \text{ (to q)} = \neg x \text{ do } p \text{ until } y \text{ do } q \]

For instance, waiting for another to catch up means not walking until the other catches up. Waiting for someone to start singing is not to start singing until someone (else) does. A symmetric wait can be solved by both starting to sing in chorus. When there is a resource conflict, a reciprocal wait where two events cannot happen at once, we get a deadlock. Albert and Alphonse politely wait for the other to go first through the door:

\[ x \text{ wait for } y \text{ to go first and } x \text{ wait for } y \text{ to go first} \]

This event type is symmetric and irreflexive, i.e. a reciprocal event type. It is rephraseable as

\[ x \text{ and } y \text{ wait for each other to go first.} \]

and further as

\[ x \text{ and } y \text{ wait for } y \text{ and } x \text{ to go first.} \]

By assumption, Albert and Alphonse cannot both go first (the doorway is too narrow). Hence the wait condition is an empty (inconsistent) event type

\[ x \text{ and } y \text{ wait for } \emptyset \]

which is equivalent to
x and y wait forever.
- a deadlock.
For the same reason, wait is an irreflexive event type. It hardly makes sense to wait for oneself to do something. (One can expect for oneself to do something.) In one sense, when there is no resource conflict, one is always in a reflexive wait, whether one does something or not. In another sense, when there is one, we have the inconsistent event of waiting oneself to do something first: One type of resource conflict is provided by reciprocal relations, like reading and writing, or talking over a one-way line.

Liveness and safety

Safety and liveness are event types of processes defined by universal or universal–existential conditions. Safe properties say that in some (perhaps all) futures, an event never (or always) happens. Live properties say that in every future an event happens at some point (perhaps all). Safety and liveness and safety are dual, one is an (existential)-universal condition, the other (universal)-existential, as such essentially topological in nature. A safe property is closed (finitely refutable), a live property is dense (not finitely refutable). An example of an event type which is neither safe nor live is (ab)\textsuperscript{\textomega}. It is the meet of the safe (locally testable) property \neg(\text{aa} \cup \text{bb})\textsuperscript{\textomega} and the live (non-locally testable) property (a\cup b)\textsuperscript{\textomega}. A universal property is at the same time safe and live.

Mutual exclusion and first come first served are safe properties. Termination, non-starvation, and guaranteed service are live properties.

Alpern/Schneider (1985) prove by a simple topological argument that every process property (tense) is a meet of a safe property and a live one. The proof is based on the observation that in the order topology (with prefix closed event types as base), safe properties are the closed events and live properties the dense ones. Any other properties can be expressed as a meet of events of these types. The observation also yields that safe properties are closed under meet and finite join. Live properties are closed under meet but not meet. Neither are closed under complement.

Alpern/Schneider (1985) note that e until f or e.f is equal to the meet \neg(\neg e<f)\textfrown f of the the safe property \neg(\neg e<f) 'e before f does not happen' and the live property <f 'eventually f'. Thus any event type (tense) is expressible in terms of until (and its order dual since). Cf. Kamp’s theorem (Kamp 1968).

Safety and liveness properties can be compared to proponent and opponent strategies in a game. All event types in one state s and its complement \neg s, for instance all sequences in (left|right)\textsuperscript{\textomega} occur in the game tree of the Urbild. Event types correspond to subtrees of the tree. There is an uncountable number of event types. A safe strategy is a proponent strategy, like a disposition. A live strategy is an opponent strategy, like a habit. Every event type is a meet of save and live strategies in the game. First order strategies make a different choice at a finite number of points in the tree, and define all and only noncounting event types. Regular expressions define all second order monadic event types.

Look at the first come first served or first in first out (FIFO) discipline, or event type of a queue as in front of a hot dog stand. The unbuffered case where only one client can be inside at once is covered by

\[(x \text{ in } \neg x \text{ ~out } . x \text{ out})\textsuperscript{\textomega}\]

which says that the first one to come out after x goes in is x. The more general case is expressed by

\[(x \text{ in } \neg(\neg x \text{ in } \neg x \text{ out }) . x \text{ out})\textsuperscript{\textomega}\]

which rules out nested visits. Nesting is also known as the stack or a last in first out (LIFO) discipline, formalised using fixpoints of events. Nesting and queuing are associated with context-free and indexed languages, respectively. There may be another duality here (Alpern/Schneider 1985, Rutten 1995).

Traffic lights

A standard example of communicating automata is a system of traffic lights. We assume three automata which describe the environment, and two traffic signals at the intersection of a main road 1 and a side road 2. There is a timer which counts n ticks (short time) and then beeps (long time).

\[
\text{timer: (tick}^2 \text{.beep)}^+ \\
\text{sensor1: (car1} \cup \neg\text{car1})^+ \\
\text{sensor2: (car2} \cup \neg\text{car2})^+
\]

The input alphabet of the street lights consists of the states of the timer and the sensors and the states of the other light. The two traffic signal automata are defined as

\[
\text{light1:} \\
\text{green.(beep}\neg\text{car1}\neg\text{car2}) \rightarrow \text{yellow |
}
yellow.(tick → red) | red.(yellow∩tick) → green

light2:
green.(beep∩car1) → yellow | yellow.tick → red | red.(yellow∩tick) → green

The main street traffic light yields when the main street is empty and the side street has a car coming; the side street light always yields to cars on the main street. The vector product
timer∩sensor1∩sensor2∩light1∩light2

of these automata defines a complex event type. Run this event type and see what happens. Assume the lights are green on the main street and red on the side street. Cars keep coming irregularly as signaled by the sensors.

<table>
<thead>
<tr>
<th>Timer</th>
<th>Sensor1</th>
<th>Sensor2</th>
<th>Light1</th>
<th>Light2</th>
<th>what is happening</th>
</tr>
</thead>
<tbody>
<tr>
<td>tick</td>
<td>~car1</td>
<td>~car2</td>
<td>green</td>
<td>red</td>
<td>no cars are coming</td>
</tr>
<tr>
<td>tick</td>
<td>~car1</td>
<td>car2</td>
<td>yellow</td>
<td>red</td>
<td>car on side street, side light goes yellow</td>
</tr>
<tr>
<td>beep</td>
<td>~car1</td>
<td>car2</td>
<td>yellow</td>
<td>yellow</td>
<td>main light goes yellow</td>
</tr>
<tr>
<td>tick</td>
<td>~car1</td>
<td>car2</td>
<td>red</td>
<td>green</td>
<td>main light goes red, side light goes green</td>
</tr>
<tr>
<td>tick</td>
<td>~car1</td>
<td>~car2</td>
<td>red</td>
<td>green</td>
<td>side street is cleared</td>
</tr>
<tr>
<td>beep</td>
<td>car1</td>
<td>car2</td>
<td>red</td>
<td>yellow</td>
<td>cars on both streets, side light goes yellow</td>
</tr>
<tr>
<td>tick</td>
<td>car1</td>
<td>car2</td>
<td>yellow</td>
<td>red</td>
<td>main light goes yellow, side light goes red</td>
</tr>
<tr>
<td>tick</td>
<td>car1</td>
<td>car2</td>
<td>green</td>
<td>red</td>
<td>main light goes green</td>
</tr>
<tr>
<td>beep</td>
<td>~car1</td>
<td>car2</td>
<td>green</td>
<td>red</td>
<td>main street is cleared</td>
</tr>
</tbody>
</table>

Table 56

This complex course of parallel events (mapped vertically rather than horizontally this time) can be construed as an unlabeled transition system in the sense of Ashby (1956). It has three orbits, or cycles, characterised by the event types ~car1∩~car2, ~car1∩car2, and car1, respectively. In the first cycle, nothing happens except time ticking away. In the second cycle, the side light turns green and lets cars pass. In the third cycle, the main light turns green and lets cars pass. An insight to be gained from this example is that the same complex course of events comes about as the product automaton of many alternative decompositions. There is choice what to consider the foreground events of the system and what as background or state. The complexity of the automaton depends on how much of the state is coded in the transition alphabet (Medvedev’s theorem).

One construal is taking the street lights to be agents and the rest environment. Here, the actions are the light changes, the rest is state. Looking at the lights alone, each light cycles through the event type (green.yellow.red.yellow)*. What the product automaton accomplishes is that the fatal event type green∩green never happens. This fact can actually be proved from our premises using the event calculus.
This it does by making the lights use the environment as a shared resource, or channel of communication. The quotient of the full automaton is a fibred product of the street light automata, in terms of category theory.

Although the same complex course of events can be split up in many ways, differences between the construals may come out when more of the state space is revealed. This is experimentation, counterfactual reasoning. This connects up the model with my analysis of causation. In fact, we can literally construe the event type cause relative to the communicating automaton so that what events cause what depends on what the component automata are and what are their connections.

For instance, in the course of events above, it seems fair to say car1 cause red1 but not ¬car1 cause red2 although there are instances of both event types car1 < red2 and ¬car1 < red1. For one thing, there are also counterinstances to the latter regularity. What is more important, we know the counterfactual theory of the traffic lights: that is, the automata whose product generates the complex course of events here. That theory, together with the boundary conditions about the environment, entails the former causal event type but not the latter, by the definition of cause. For plugging in light2 as background theory and beep as a boundary condition, we can prove

\[ \text{light2} \cap \text{beep} \rightarrow \text{car1} \leq \text{red2} \]

but we can’t prove

\[ \text{light1} \cap \text{beep} \rightarrow \neg \text{car1} \leq \text{red2} \]

without adding the unpredictable event car2 to the premises. It is the joint event car2car1 that qualifies for a cause here, given the theory light1. By my characterisation of agent, the cars are agents here, for they are driven by nondeterministic automata. All the other automata are deterministic.

Using the event-object duality, the connections between event types can also be projected on the object domain and implemented as shared variables in event types. This leads to the dataflow view of communicating events. This option is studied in the next section.

**Boy and ball**

Look at an animation of a boy bouncing a ball. This event type can be decomposed into the action of the boy and the action of the ball. The boy is an agent, so he has aims and means (preferences and strategies), plus, while the ball only has one strategy. Counterfactually, counting just gravity, the ball always falls. However, this default strategy is counteracted by the boy’s strategy of throwing the ball, so the sum or product of the two (equivalently, the conditional strategy of the ball given the throw), is that the ball goes up. So we get Newtonian dynamics in a qualitative way here too.

One might say they are playing a game except it is a one-person game. Only the boy is playing, because the ball has no strategy choice. (A variant of the game is where there is boy, ball, and dog. This is a two-player game, because the dog has strategy choices.) The ball’s unconditional strategy is quite simple; it is the product of that with the boy’s strategy which makes the game interesting. Which is another case of category theoretic duality of product vs. quotient, refinement and simplification.

So what are the strategies? The ball has only one unconditional strategy:

\[ \text{fall} \]

which is conditionalised as follows:

\[ \begin{align*}
\text{x be on y} & \rightarrow \text{x stay on y} \\
\text{y pushed x up} & \rightarrow \text{x go up} \\
\text{x go up and x free} & \rightarrow \text{go on up} \\
\text{x go on up and free} & \rightarrow \text{x stop} \\
\text{x be at rest and free} & \rightarrow \text{x fall} \\
\text{x fall on y and y hard} & \rightarrow \text{y push x up}
\end{align*} \]

The boy has the following strategies:

\[ \begin{align*}
\text{hand level} & \rightarrow \text{hand down} \\
\text{hand down and ball up} & \rightarrow \text{hand down} \\
\text{hand down and ball down} & \rightarrow \text{hand level} \\
\text{ball in hand and hand level} & \rightarrow \text{hand down} \\
\text{ball in hand and hand down} & \rightarrow \text{hand up} \\
\text{ball in hand and hand up} & \rightarrow \text{free ball}
\end{align*} \]
ball up and hand up → hand down

The boy’s strategy is conditioned on the ball. One can’t play catch without following the ball, unless the timing is perfect. (That is how the animation works.)

The physics is incomplete: there is something missing about how hard the ball is pushed up. At least comparison. push up must be harder than the gravity’s pull down, otherwise the ball won’t fly free.

But the cybernetics is there: there is a feedback loop between the ball and the boy. The feedback loop makes two opposite processes cancel out so an equilibrium ensues. The ball staying on the hand is an equilibrium between hand being held up and ball not falling. Another equilibrium is between the push of the throw and the pull of the earth. The push has momentum, which is canceled by the pull of the earth. The azimuth of the ball is an equilibrium. There is also equilibrium in the entire animation in terms of a higher order state of steady oscillation.

From the perspective of the previous section, the boy and ball are communicating automata. We may formalise agents as transducers: internal states are internal events, i/o alphabet are perception and action events. Take projections into different alphabets. What the boy does is the projection of his agency to the output alphabet. Some projection of what the ball does (the window accessible to the boy) is what the boy perceives. (What the ball does to the boy). The entire game is what they both do, or what they do to one another.

What will this exercise give? A way to describe a complex looping event as coupled simpler looping events, with causal links between them. An insight into event decomposition, and a connection between my theory of events and cybernetics, robotics, theory of parallel and distributed processing.

For instance, the ball falls when free, so its loop is a directed one. The boy throws the ball when he has it, so his loop is upward directed one. Coupling the two gives an oscillation.

Why does the boy have to see the ball? Because he has to put his hand where the ball will be. This is a strategy he has to have, and he won’t have it unless he knows how to put the hand where the ball will be, which entails he knows where the ball will be, which he knows by seeing the ball. This connects up the boy and ball model to my game model of action.

The boy and the ball are transducers. The boy’s input alphabet are the events which he perceives. His output alphabet are the events which he does. The relation between the boy and the ball are represented as pairs occupying the two tapes. The internal events of the boy are represented by his state alphabet. Communication arises by sharing of tapes.

The difference between the boy and the ball is that the boy is a nondeterministic automaton: he has strategies, the ball is deterministic. This should allow representing at once the causal relations and the game theoretic ones. I’d like to also allow a quantitative refinement of the comparative model, so that one can use Newtonian dynamics if one wants.

Parallel and distributed events

There is a plethora of formal models of parallel and distributed events and communicating processes in computer science. They include temporal, dynamic, process, and game logics, communicating automata (Hoare 1985, Petri nets (Petri 1962), action calculi (Milner 19??), and flow algebras.

Though my event calculus is not specifically geared toward parallel or distributed event types, some general notions of the field may be mentioned here. One is the distinction between simultaneity and parallelism/concurrency. In the event calculus defined here, meets and joins of events happen together in the sense of being parts of the same (conjunctive or disjunctive) event type, but not necessarily at the same time, unless one of the events is a time. Simultaneous events are events which happen at the same time. Independent concurrent events can even happen one after another. The main thing is that no particular temporal relation is implied.

Another is the insight that failure of the sort of independence implied by concurrency involves the presence of constraints between events. They may be thought of as resource conflicts or as sharing of resources. The common abstraction is the category theoretic one of fibred product, or product subject to a law. When events have to happen at the same time or cannot happen at the same time, there is some shared parameter which takes identical or distinct values on them.

Take examples. Construed as propositional constants, rain and wind are compatible, while rain and ¬rain are not. However, with time or place as parameters, rain and ¬rain can happen at the same time, at different places, or at the same place, at different times. Event types rain at t at p, ¬rain at t at p are incompatible just when t and p are atoms relative to rain.

Process communication and resource conflicts follow the same logic. Aristotle eats and Socrates eats cannot happen at the same time if fork and knife are atomary relative to the two dining philosophers and time. Process communication shares a variable (a channel or message), resource conflicts fail to do so.
Passing trains

Another parade example is that of two (or more) trains on a single railway line with two (or more) stations. The event type to solve is

\[(\text{train1 }\cup\text{ train2 }\text{ at station1 }\cup\text{ train2 }\text{ at station2} \cup \text{ train1 }\cup\text{ train2 on rail} \cup \text{ train1 }\cup\text{ train2 at station1 }\cup\text{ train2 at station2})^+\]

The constraints are that the trains and the places are atomary, i.e. a train cannot be at two places at once, and a place cannot hold two trains at once, and that motion is continuous: one cannot move from one place to another without passing through places in between.

The result is that the trains can only move in one direction or stop; they cannot pass one another. This is easy to prove in event calculus. The constraints can be stated as follows.

\[\text{train1 }\cap\text{ train2 }= \emptyset\]
\[\text{station1 }+ \text{ rail }+ \text{ station2}\]
\[\text{station.rail.station2}\]
\[x \text{ at } p \text{ at } t \iff \neg x \text{ at } \neg p \text{ at } t\]
\[x \text{ at } y \text{ at } t \iff x \text{ at } y \text{ at } t\]

The first line tells that the trains and places are atomary, and that the rail line is continuous. The second line says that an object cannot be at two places at once and two objects cannot be at the same place at once. The third line expresses continuity of motion.

Look at chains of events of length 3. Multiply out the event type to solve and canceling out event types which violate atomicity. Assume train1 starts at station1 and train2 at station2. What happens? Looking only at one half of the symmetric options, we have

\[(\text{train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 at station1 }\cap\text{ train2 at station2}) \text{ – nothing moves}\]
\[(\text{train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 on rail }\cap\text{ train2 at station2} \cap \text{ train1 at station1 }\cap\text{ train2 at station2}) \text{ – train1 starts for station2 and stops, train2 stays put}\]
\[(\text{train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 on rail }\cap\text{ train2 at station2} \cap \text{ train1 at station1 }\cap\text{ train2 at station2}) \text{ – train1 starts for station2 but returns, train2 stays put}\]
\[(\text{train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 on rail }\cap\text{ train2 at station2} \cap \text{ train1 at station1 }\cap\text{ train2 at station2}) \text{ – train1 starts for station2 and returns, train2 starts}\]

Further iteration does not produce anything new. This is another deadlock.

What can’t happen is that the trains share a place (a collision). Another thing that can’t happen is that the trains change places (that contradicts continuity). The problem is immediately solved by making the railway two-way, allowing trains to pass. Then we obtain the event type

\[(\text{train1 at station1 }\cap\text{ train2 at station2} \cap \text{ train1 on rail }\cap\text{ train2 on rail} \cap \text{ train1 at station2 }\cap\text{ train2 at station1})\]

Distributing the event type for each train, this is the meet of the continuous motions

\[\text{train1 at station1}\text{.train1 on rail}\text{.train1 at station2} \text{ – train1 goes from station1 to station2}\]
\[\text{train2 at station2}\text{. train2 on rail . train2 at station1} \text{ - train2 goes from station2 to station1}\]

entailing also the event type the trains pass on the rail. This works like a clockwork.

Quantifiers, games, and automata

There are aspertual pairs of verbs which relate like try and succeed. One such pair is seek and find. Games connected with these verbs were related to the semantics of quantifiers in Hintikka (1973b). The language game of seeking and finding can be schematically represented as the following automaton (van Benthem 199?):
To search for something, one looks for (tries to find) an item from the domain of search. If the domain is empty, the search fails. Otherwise the object picked is checked against what is being looked for. If there is a match, the search ends with success; the object is found. Otherwise the candidate is rejected from the domain and the loop repeats. This language game of seeking and finding has a winning strategy if the thing sought for exists in the domain reachable by the choice function. If the choice function is good, it can hit upon the right choice at once. Given liberal enough notions of can and find, to exist means can be found (Hintikka 1973b). This is the idiom for existence in Swedish and doubtless in other languages as well.

van Benthem (1985a,b, 1986:174) points out that all first order quantifiers can be defined by noncounting automata (logical, i.e. permutation-invariant aperiodic automata with one-state cycles). An example of a finite-state definable non-first order quantifier is an even number (cf. van Benthem 1986:35). An example of a non-finite-state definable quantifier is most. (Most and other quantifiers which compare numbers can be implemented by push-down automata, van Benthem 1985.)

Games can be played as simultaneous or sequential games (Carlson 1994). The difference is reflected in the strategy sets of the players. A simultaneous game of Left or Right has no winning strategy, while a sequential game can always be won by the second player. Language games of seeking and finding can also be played as simultaneous or sequential. A simultaneous game with two opposite quantifiers is not generally determinate. For instance, a quantifier version of Left or Right is only determinate in a unit domain. This result can be used for a semantics of the definite article.

The game metonymy

Summing up: the event calculus allows explicating an extensive metonymy in diathesis between notions of want/indifference, able/happen, the causative duality cause/let, active/passive diathesis, (im)perfect(ive) aspect, reflexive/obviative reference, possession, and source/goal roles. An agent able to do what he wants causes things of himself and gets good things to himself, while things happen to a patient whether he wants them or not, he lets others do bad things to him or take good things from him.

These connections can be made logically binding in the context of a deterministic zero-sum game. The winning player controls the outcome of the game and causes things to happen. The losing player lets the outcome happen and takes what is coming to him. Determinism and the zero-sum assumption imply that others (can) cause what one (must) let happen.

The practical outcome of the game metonymy is that a language can choose any one of the means just mentioned to implicate the rest. A student of diathesis morphology must be count with this multiplicity of possible solutions. For instance, a transitivising morpheme can be etymologically a preferential or ability modal, an aspect, a causative, motion or change verb, a reflexive pronoun, or a source case, to mention the most common choices. Thus semantics leaves a lot of leeway to the game. The constraints come from morphology, typology, and history. Cree (quod vide) is a good example.

Diathesis morphology

The causal chain appears in barest outline only in a minority of languages and clause types in them. Generally, languages hide it from view through morphological and syntactic combinatorics. The tools of this trade are word order, auxiliary verbs, roles, cases, and agreement. The thrust of the chapter is that these various expressive means provide interchangeable and compatible perspectives on one and the same chain of events. The compatibility in particular allows redundancy in the representation: the different means can be and are combined in languages in different ways.

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192 van Benthem uses acyclic in place of aperiodic.
The versatility of the combiners leaves a lot of leeway to reconstructing word order and morphology. It is not even necessary to assume only one correct analysis. This liberty could be used to seek for more exceptionless morphological and word order universals.

**Binary relations**

Note the following circumstance. If event types (regular expressions) wind and cloud and rain are disjoint, their concatenation wind.cloud.rain entails the join wind< ∩ cloud< ∩ rain. This meet is commutative, while the concatenation is associative but not commutative. It follows that cloud.wind.rain entails (wind< ∩ cloud<) ∩ rain is equivalent to wind< ∩ (cloud< ∩ rain) but not to rain.wind.cloud.

The entailment does not amount to equivalence, however. For one thing, the connective <∩< or, ≤ does not entail contiguity of the event types wind, cloud and rain. But connectivity can be added as an extra conjunct, as for instance in

\[(\text{wind} \cap t) < \cap (\text{cloud} \cap u) < \cap (\text{rain} \cap v) \cap \text{tuv} = \text{cloud.wind.rain} \cap \text{tuv}\]

Let us now try transposing this decomposition to the object domain and the algebra of relations. The above temporal decomposition does not quite capture the intended meaning of a relational event type like *man drink water*. It does entail that there are three temporally contiguous events of a man doing something, a drinking event, and water being subjected to something. But it misses the point that these subevents participate in the same event. We need more glue to join the three events into one. There is an event token e = xry in which each event type participates by taking the roles of x, r and y in it.

\[(\text{man} \cap x) \cap (\text{drink} \cap r) \cap (\text{water} \cap y) \cap \text{xry} = \text{man drink water} \cap \text{xry}\]

What is looking at us here is a Davidsonian analysis of events (Davidson 1967, Parsons 1990). Transposing into another familiar notation, each of the three participants of the relation *man drink water* can be thought of as a partial description of the relation, combined by unification, as usual in unification based grammar. The order of the words is coded in the roles of the graph, which allows unifying them in any order.

\[\langle \text{arg1} = \text{man}\rangle \cup \langle \text{pred} = \text{drink}\rangle \cup \langle \text{arg2} = \text{water}\rangle = \langle \text{arg1} = \text{man} < \text{pred} = \text{drink} < \text{arg2} = \text{water}\rangle\]

We may further ask what sort of an object e is. If we think of the relation *man drink water* as a relation table, then three conjuncts of the above formula correspond to projections of the table, which combined back to a join by meeting their cartesian product with the constraint. e then corresponds to a select operator on the table, choosing certain rows from that join. For equivalence, these are the rows that correspond to the original table, so in fact e entails the original relation *man drink water*.

A perspective which combines this analysis with modality is to construe e as a strategy. There is an event connecting the three participant types if and only if the three are causally related: the man causes the drinking event, and the drinking event causes the water to disappear into the man. By transitivity, the man causes the disappearance of the water. The generality of this causal relation depends on the size of e. If it is 1, allowing anything, then we have just temporal succession. If it is atomary, i.e. allows just one row (one token course of events), then we have an existential event statement.

This interdependence allows us to construe causal relations as specialisations of temporal relations. Causal consequence *cause* is a specialisation of temporal succession *become*. Acause is a special case of beginning, and an agent becomes a special case of source.

These observations pave the way to an elegant formalisation of the interdependence of cases, roles and word order. It is well known that case morphology and word order are dually related in the following sense: on the whole, the more of the former, the less of the latter, and vice versa. This duality will be given formal status further on.

This grammatical analysis conforms closely to the event interpretation of concrete transitive event types. Something the man does (a subevent of the object *man*) precedes and causes a change (a subevent) in the object *water* by, through, and within the event type *drink*. The drinking event is the path or instrument of the change. Word order is iconic on events. True, and well known; the novelty is that the calculus actually makes this a formal fact.

However, the formal analogy is also detachable from this connection. Purely notationally, the above decomposition of a binary relation is a harmless variant of more familiar ones. One can think of it as representing a binary relation as a triple or vector, and of the application of the relation to its arguments as pointwise addition of the vectors. The space-time analogy is not necessary for that.
Anaphora

There are two different, but dually related ways in (natural or formal) language to say several things about the same thing. One is variable sharing, the other is function composition. The variable indexing method has an object (variable or index) in two places. The function nesting method has two objects (slot and filler) in one place.

A formal language can be built up so that it only contains relations and variable sharing (like Prolog). Schönfinkel (1924) showed that a formal language can also be built up so that it only contains functions and combinators (like Lisp). Natural languages use both methods of reference tracking. These methods are exemplified in natural language by coordination/coreference \((it \ happened \ and \ it \ was \ unexpected)\) and subordination/modification \((it \ happened \ unexpectedly)\). The two methods are related by combinators like the Schönfinkel substitution operator \(S\) by setting \(it = x\), \(happen = g\), \(unexpected = f\), \(ly = S\).

\[ Sfgx = fxgx \]

Another example of variable elimination is coordination reduction: \(I \ come \ and \ I \ go = I \ come \ and \ go\) is an instance of the binary composition combinator

\[ Ffghx = fgxhx \]

by setting \(x = I\), \(f = and\), \(g = come\), \(h = go\).

There is a plethora of approaches to anaphora. One dimension of classification is the syntax-semantics-pragmatics axis which measures how much of the logic of anaphora appears in the metalanguage used to describe anaphora, and how much is left implicit. The pronoun nominalisation transformation of generative grammar exemplifies the syntactic end of the scale. The assignment update semantics of anaphora (van Benthem 1996) exemplifies middle ground.

- anaphors are variable binding operators, such as reflexive combinator \(C\).
- anaphors are dynamic modal operators on assignments.
- anaphors are definite noun phrases, for instance \(he\) means ‘the male one’.

All perspectives have their attractions. The first one fits bound anaphora. The second explains dynamic scoping of anaphors. The third one captures the observation that all nominals are contextual, not only definites or pronouns (Perry 1993). I have expressed a preference for having everything out in the calculus, avoiding a separate formal semantics and pragmatics. How would the above theories be placed in such an approach?

A connection may be provided by proof theory, like sequent calculus. Consider a text a sequence of premises, which are turned, using proof theoretical steps, into sentences, where the first approach applies. Discourse grammar guides the decision which sentences can be combined. Combinatory logic then combines the anaphors with their heads. Say there is a discourse

Caesar came. He won.

This is reconstructed by dialogue game rules into one move:

Caesar came and he won.

This is shown in the calculus to be equivalent to either one of

Caesar came and Caesar won
Caesar came and he won.

The discourse interpretation work happens in deciding what moves are combined into one, before applying combinators. Recall here that \(cause\) is a specialisation of \(\leq\) which in turn equals \(<\cap<\). Formally:

\[
\begin{align*}
\text{caesar came } & \leq \text{ he saw} \\
(\text{Caesar} \cap \text{came}) & <\cap< (\text{he} < \cap \text{ saw}) \\
(\text{Caesar} < \cap \text{ he}) & < \cap < (\text{came} < \cap \text{ saw}) \\
(\text{Caesar} \cap \text{he}) & < \cap < (\text{came} < \cap \text{ saw}) \\
(\text{Caesar} < \cap \text{ Caesar}) & < \cap < (\text{came} < \cap < \text{ saw}) \\
\text{Caesar came } & \leq \text{ Caesar saw} \\
\text{Caesar came } & < \cap < \text{ saw}
\end{align*}
\]

The last two alternative lines depend on which combinator reduces \(he\): either duplicator, from \(\text{Caesar} \cap \text{he}\) to \(\text{Caesar} \cap \text{Caesar}\), or identity, from \(\text{Caesar} \cap \text{he}\) to \(\text{Caesar}\). Semantically, both are legitimate, given that \(he\) means the male. They can actually be inferred from one another:
Caesar ∩ he = Caesar = Caesar ∩ Caesar = Caesar ∩ Caesar ∩ he.

The dynamic perspective on subject tracking as a path of objects along which events happen helps explicate the notions of reference tracking and obviation. The idea is this (Barwise 1987, Groenendijk/Stockhof 1988, van Benthem 1991:226, 1996). Construe a sequence of event types as one-place predicates about a subject. A discourse can go on about one and the same subject or change subject. Let the initial subject of a discourse be denoted by 1. Compose sentences about the same subject left to right subject to consistency. Then texts Caesar came. He won. and He won. Caesar came. are represented respectively by


Assuming he equals the male, the first formula consistently evaluates to Caesar, while the second formula evaluates to null unless the initial subject equals Caesar. It does in e.g. He won. Caesar did, I mean. where I mean indicates self-repair. Another consistent reading is obtained by assuming an obviation between the sentences, which gives the consistent two-topic discourse


Identity of reference within a lexical type is marked with reflexive morphology. A referential principle of shortest access (Carlson 1988) explains the implicature of disjoint reference outside them.

The device known as obviation (Klaiman 1991) uses deixis to distinguish what is being talked about from what is not. Proximal deixis mark topic (dialogue subject, Carlson 1983), distal ones non-topic. For an example how this works, see section on Cree.

Another method is switch reference which marks identity or nonidentity of subject on the connective ∩x and he ∩¬x and not he defined by the identities

(x p) ∩x q = x p ∩ x q = x (p ∩ q)

Assignments

An assignment is a function from variables to values, a dual of a vector of values. This is the duality of vectors and functions. A relation table is a set of rows, or equivalently, a set of functions from column names to values. This means we can consider a relation as a set of assignments. This is a good starting point for an explication of natural language marking of argument roles.

From this point of view, different methods of role marking roles are about choosing column names for the relation. Fixed word order uses linear position (time) directly as the domain of the assignment. Directional case marking gives names to linear positions.

But these are only some of the possible choices. Any properties which constrain the indexing of argument positions will do. Pronominal indexing uses roles in a dialogue game to index argument positions. Number and gender agreement index by number and gender. Bantu languages use noun classifiers. Inverse voice languages appear to use an animacy hierarchy (but see section on inverse voice).

Formally, person marking of the type he loves her, Bill, Sue can be represented as the meet of three assignments, the first of which represents the relation algebra meet love ∩ female.male. the second the relation join Bill_U_Bill or the symmetric closure of Bill_. and the third the same for Sue. These assignments yield a unique table row in the meet. Meet is commutative, so is word order.

The use of the animacy hierarchy to assign roles is particularly interesting. Basically, what a direct role assignment says is something like animate love ¬ animate. But the assignment is comparative, i.e. relative to a context set from which the choice is made. The animacy hierarchy says human<animal<object. In the choice set of the man Bill and his donkey Sue it assigns Bill to the animate end of the hierarchy and Sue to the inanimate end. We get a relation algebra formalisation as

love ∩ animate. ¬ animate ∩ Bill_U_Bill ∩ Sue_U_Sue

which again succeeds picking out a unique table row from the relation. (The proof rests on the premises that Bill is human and Sue is an animal, i.e. Bill = Bill ∩ human and Sue = Sue ∩ animal and the animacy hierarchy which entails the relative assignments:

animate. ¬ animate ∩ human.animal = human.animal

Word order

There are correlations between diathesis and word order, due to iconicity and information structure. By iconicity, early positions are unmarked for source roles, late positions for goals. Also iconically, old information, including dialogue
subject, comes early (Carlson 1983). Active voice marks the agent as old and the object as new. Passive voice does the opposite. Accusative languages are subject initial, ergative languages object initial.

One candidate for a word order universal is inversion is marked. A strong form of this universal is that every inversion must carry a mark. Covariant, iconic order of presentation of events needs no marking.


\[
\text{Nada bayi yara balgan. I (nom) the man (nom) hit. ‘I hit the man.’} \\
\text{Nayguna bangul yarangu balgan. I (acc) the man (erg) hit. ‘I was hit by the man.’}
\]

This could be developed into a markedness theory of word order analogous to editing distance. What would follow? SVO order should be the unmarked order. A pure analytic language without any marking whatsoever would have to be SVO.

Counting just character inversions, VSO and SOV are one step away from SVO, VOS two. If we respect operator structure, the flip S(VO) to (VO)S is an inversion, while VSO counts as extraction. Vennemann’s (1973:41, Foley/van Valin 1981, Bybee 1985) principle of natural serialisation prefers prefix and postfix orders S(V(O)) and ((O)V)S because they preserve operator-operand order.

Instead of searching top down for a formal metric to summarise the statistics, I prefer to study to the developmental paths and grammatical solutions along which the different patterns are reached. The details help predict the metric as well as the other way round. Form and function follow one another, as they do in natural history.

SVO word order characterises decontextualised, planned speech. Fronting and doubling: by left and right dislocation (Carlson 1983) belong to unplanned speech and allow for contrastive topics. Leontjev (19??) found internal speech follow a rhyme initial, right dislocated order. New orders are likely to arise from such compositional structures with transparent functions.

How does a language invert word order? One attested scenario is that an old order of words gets bleached beyond usability through cliticisation and affixation of unstressed pronouns, so that new full form pronouns are needed to support them. Doubling is a midway station in a process of inversion: Latin, for instance, is head final, with suffixal person agreement. In French, personal pronouns have become cliticised to the following verb, so that new emphatic order iconic to the causal chain is represented directly by boy pat dog, as an instance of the event type boy_dog. The order of arguments can be inverted using two argument abstraction steps.

But then associativity fails: dog \_ \_ (pat \_ \_ boy) is equivalent to, but denotes a different event from (dog \_ \_ pat) \_ \_ boy. This could be taken as a transscendental deduction of binary branching phrase structure in a configurational language – currying, in fact.

Rich morphology formally allows freedom in word order in the calculus. For instance, Warlpiri word order reminiscent of poetic Latin gets the roles right thanks to cases: (English is not much worse off really, it just needs nominal support for its adjectives.)

\[
\text{Tjantunku iju yalkunu virinki, dog (erg) me (acc) bit (past) big (erg) ’A dog bit me, a big one’.} \\
\text{dog_ \_ I \_ I \_ bite \_ big_ = big_ \_ dog \_ big \_ bite I}
\]

Roles

The arguent frame schemas allows positional definition of a system of semantic roles (Jackendoff 1976, Van Valin 1997:85). The first argument of be is a subject and the second argument is a predicate, the argument of at is a location, the initial event of a sequence of events is source, and the final event is goal. Positions in the middle of a sequence of events are known as the path.

Role definitions like this define a translation of positionally defined case roles into a Davidsonian event representation where roles are defined as labeled binary relations between a situation and its participants (Parsons 1990:100, Vlach
Instead of trying to prove either notation wrong (Verkuyl 1993), I find it more useful to provide translations. There is no conflict between (de)compositional and Davidsonian analyses of predications, if a translation is supplied by positional definitions of argument roles. One difference is what postulates are added: in the functional account, associativity, commutativity, and optionality; in the relational account, obligatoriness.

In the special case where a role is unique, it can be defined in functional style as a selection operator (Löbner 1985, 1988:188fn).

The abstraction operator gives a neat way to formalise positional roles.

\[
\begin{align*}
\text{subj} & : \mathsf{x} : \mathsf{x} \text{ be } _\_ \\
\text{pred} & : _\_ \text{ be } \mathsf{x} \\
\text{loc} & : \mathsf{x} : \text{ in } \mathsf{x}
\end{align*}
\]

Type equivalences allow applying the above definitions to further formulas. Note that these definitions generate morphisms between roles. For instance, subject, copula, and predicate are related like source, path, and goal.

My roles are rather role types. A feature that this analysis shares with my treatment of aspect is that case roles are not exclusive, but one role can be the generalisation of another (Fillmore 1971:52; Cook 1972, Gensiniene 1987) and one argument can simultaneously occupy different roles with respect to different subevents (Lapolla/Van Valin 1997, Van Valin 2002). This is among the desiderata for thematic roles mentioned in Frawley (1992:218, §5.3) and Parsons (1990:80). More than that, the present account defines an inheritance lattice among roles: instrument is a kind of path, agent is a kind of source, object is both subject and goal, etc, which is another desideratum. We shall see that already this much structure makes literal sense of much natural language talk about change.

The role types direct and oblique allow a simple characterisation in terms of the event type \( \mathsf{be} \). A direct role is a subject role. In virtue of their definitions, this will cover subject, object and indirect object of a dative inversion. An oblique role is a nonsubject role. This will cover objects of cases and prepositions.

My notion of role is quite different from approaches where roles are primitive. Going through conditions listed in Klaiman (1991:30), my roles don’t satisfy independence: they are interdefinable with event types and logically related to one another. They do not satisfy completeness (every argument place has a role): it is up to languages to decide which paths into an event type deserve a label. They don’t satisfy distinctness: given superposition, more than one phrase can fill the same role. Conversely, one phrase can play many different roles, both because role definitions overlap and because roles are relative to frames. A phrase can have different roles relative to different frames within the same event type. More than that: phrases may have abstract “underlying” roles relative to some transform of the surface event type. I put “underlying” in quotes to warn that such inferred roles need not be more primitive than the surface role in any sense.

Grammaticalisation of roles on the head characterises head marking languages (Nichols 1986). Voice systems based on this are known as focus systems, e.g. Mayan, Tagalog (Klaiman 1991).

Increasingly complex roles can be defined on increasingly complex event types, such as (Genusiniene 1987:39):

- actor for the autocausative role \( \mathsf{x} \mathsf{x} \text{ do } \mathsf{x} \)
- patient for the join \( \text{subj} \mathsf{theme} \mathsf{obj} \)
- initiator for the agent of a factitive event type \( \mathsf{x} \mathsf{x} \text{ do } \mathsf{y} \text{ do } \mathsf{y} \)
- content for the content of an image relation: \( z : \mathsf{x} \text{ imagine } y \text{ as } z \)
- experiencer for the holder of an image of a source: \( y : \mathsf{x} \text{ image } y \)

The need for a disjunctive role patient is doubtful, given that theme and object are specialisations of subject role anyway. There is no end to possible roles – at least as long as there is no end to event types.

Cases

Semantic cases are closely related to roles, sometimes treated as more or less the same thing. (Fillmore 1968). More accurately, cases and roles are dual (inverses), as shown by the following equivalence.

\[
\text{case } n \cap v = \text{role } v \cap n
\]

In words: the same event type can be obtained by applying a case to a nominal event type as by applying a role to a verbal one. For instance, we may define nominative case by the following identity:

\[
\text{nom } n \cap v = \text{subj } v \cap n
\]

Applying the positional definition of subject role, we can unpack this implicit definition into an explicit one which shows that nom indeed denotes the inverse transducer of subj.

\[
\text{nom } x \text{ be } _\_ : x
\]
Using this insight and the role definitions above, we can find definitions for the locative cases and later on extend the duality to more complicated ones. I won’t bother to introduce new names to the locative cases, but use the dual role names.

- **loc** _in x: x_
- **source** _x<: x_
- **goal** _<x: x_
- **path** _<x<: x_

This is not meant as just an analogy, but can be taken literally: to school is the event type of events which end at school. The duality of roles and cases allows rewriting Davidsonian event formulas in a more English looking form. Instead of saying stiltedly ‘my source is Finland’ one says more colloquially ‘I am from Finland’. Individuals being events, the latter is correctly formalised as I be from Finland, that is I ⋂ in Finland ⋂ now.

**Grammatical** cases constitute abstract objects of an algebra of cases. The initial object is nominative, which does nothing. It is that degenerate case of locative where _in x = around x = at x = x_. Dative and accusative are instances of goal. Genitive, the case of possession and relation composition arises as a grammaticalisation of any of three locative cases of source, location or goal. Instrumental is a grammaticalisation of path, which in turn is an instance of locative. The complexity of systems of grammatical cases can be measured by the complexity of the event types which distinguish them.

A common way of dealing with the family resemblances of case systems in linguistics is to define case prototypes and different languages as deviations from them. A dual way is to develop an algebra of cases so that different systems constitute different selections from a grid of possibilities. The first methods shows how say, Latin and Greek dative deviate from a prototype dative by a series of joins and meets of uses. The second method maps the coverage of each in terms of a sum of uses.

**Persons**

Doubling, or agreement, is perhaps more commonly construed as coreference rather than operator application. But coreference and operator application are interdefinable using combinators. Take doubling in a hypothetical Australian language:

**he kill him kangaroo man**

In terms of combinatory logic, the pronoun _him_ acts as an identity combinator, while _he_ is an inversion by the definitions

- **him** _x = x_
- **he** _p x: x p_

Together, they get us from the doubling version above to the iconic word order version below:

**man kill kangaroo**

A word order trend can be predicted from the operator analysis of person agreement affixes. In this construal, the agent/subject and absolute/object agreement affixes are in effect notational variants of the abstract verbs _cause_ and _become_, respectively. The prediction is that when they are curried on either side of the verb, they too take their nominal arguments on the opposite side in mirror image order.

This prediction appears to be borne out in many languages, including English. Tagalog and Menomini are verb initial languages where operator order is the exact mirror image of the order of operators in the usual prefix notation. Under this construction, these languages are regular postfix operator languages.

In Upriver Halkomelem., the order is the reverse, but nested in the same way. The longer form is functionally an active, the shorter a passive.

- **t∂s-l-xw-∂s θuλ’a t∂ swiy∂q∂**. **bump accidentally him she woman the man** ‘The man bumped accidentally into the woman.’
- **t∂s-l-∂m θuλ’a t∂ swiy∂q∂**. **bump accidentally self she the man** ‘The woman was bumped into by the man.’

Another Salish language Lillooet (Davis/Demirdache 2000), which has the same word order pattern, is described as ergative. Yet another, Bella Coola (Croft 2001), marks the agent with a case. The data on Halkomelem in Croft (2001) is too scanty to make definite guesses about the morphology.

One prediction would be that morphology is simpler when the agreement markers and the arguments are in mirror image order (nested or context free, not cross-serial or indexed). This is the case in some Australian languages with split ergative pattern (Ritter/Rosen 2001, Trask 1979, Croft 2001). According to Croft (2001), accusative agreement marking complements ergative case marking but not vice versa.
The interdefinability between the head marking, dependent marking, and doubling solutions to indicating argument structure could be illustrated like this. The head marking, or role frame goes like who kills whom are the man and the kangaroo. The dependent marking, or case frame goes The killing was by the man on the kangaroo. The doubling, or agreement frame goes he kills him, the man the kangaroo. All are correct and compatible views of the same event. They instantiate the duality of variables versus operators, or categorial/Lambek calculus versus context free/indexed grammar.

The role-case duality formalises a typological distinction between head-marking and dependent-marking languages. Together with the positional definition of roles, it makes the entire argument structure diagram commute: word order, voice, and cases are interchangeable exponents of diathesis. I elaborate on the syntax-morphology duality in the section on word order.

**Doubling**

The role-case duality is a locus of neutralisation for head marking and dependent marking. The sequence go to gods can be parsed as a head marking (go to) gods or as a dependent marking go (to gods).

Although interchangeable, the diathesis marking methods are not mutually exclusive. Doubling makes sense too, as in Latin (or English). Recall here that cause is a specialisation of ≤ which in turn equals \(\cap\):

\[
\begin{align*}
\text{ire ad deos} & \quad \text{go} \cap \text{<gods} \quad \text{‘go toward gods’} \\
\text{adire deos} & \quad \text{go<} \cap \text{gods} \quad \text{‘approach gods’} \\
\text{adire ad deos} & \quad \text{go<} \cap \text{<gods} \quad \text{‘approach toward gods’}.
\end{align*}
\]

Doubling creates a locus for neutralisation between ‘go’ and ‘be’ in the Portuguese verbs ir and ser which share the perfective foi: nunca foi a Italia represents the frame pf be in Italy on both readings.

Interestingly, the relation of motion verbs to directional prepositions turns out to be a denotational difference. For go denotes the event type \(x \in \neg y \times y \times y\) while to denotes its suffix, result state, or goal \(x \in \neg y \times y \times y\). This means that it is formally correct to say that go causes to, for go cause to equals \(x \in \neg y \times y \times y \leq x \in \neg y \times y \times y\). This is provable in the calculus.

The possessive goal case for can be analogously construed as a denotational variant \(x\) cause \(y\) be with \(x\).y be with \(z\) of the transfer of possession give to be described below.

To sum up: word order, case, role and pronoun marking can be related to one another using meet and concatenation:

\[
\text{go to gods} = \text{go<} \cap \text{< to gods} = \text{go to} \cap \text{< gods} = \text{go to them} \cap \text{< gods}
\]

The only difference between the last two formulas is that Jane is superimposed to an explicit placeholder. Here we have a formal proof of the well known principle of language typology that word order and morphology are complementary.

A good display of the complementarity of case, voice and person marking is Southern Tiwa (Klaiman 1991:17):

\[
\begin{align*}
\text{hliara-n ibi} \cdot \text{‘u’u-mu-ban} & \quad \text{woman pl they them baby see past ‘The women saw the babies’} \\
\text{‘u’u-n i-um-chen hliara-n baby pl they see pass past woman pl ‘The babies were seen by the women’} \\
\text{ti-khwien-wia-ban} & \quad \text{‘i-ay I him dog give past you to ‘I gave the dog to you.’} \\
\text{ka-khwien-wia-ban} & \quad 1 \quad \text{you dog give past ‘I gave you the dog.’} \\
\text{seuan-ide wan-ban na} \cdot \text{ay man sg come past 1 to ‘The man came to me.’} \\
\text{in-seuan-wan-ban (na)} & \quad \text{to man come past I? ‘The man approached (me)’}\text{.}
\end{align*}
\]

The first, third, and fourth examples use pronouns, the second and last examples use voice, and the third and second last have cases.

**Control**

Control as a diathesis notion (Klainman 1991, Givon 1975) means symmetric ability, Aristotle’s *eadem potentia oppositorum* (Klainman 1991:§3). Its dual is contingency: neither the event or its complement can be caused or prevented. A contingent event just happens, uncontrollably or accidentally.

It seems a cross-linguistic tendency for the dual meanings able/happen to cluster on the same device, or form an open-closed aspect pair (e.g. Lillooet: Davis/Demirdache 2000:113, Malagasy: Travis 2000:175, Tagalog: Travis 2000:178, McFarland 1976, Thompson River Salish: Klaiman 1991:152). Thompson River Salish seems to have a full paradigm of affixal modals able/can’t help and control/happen.

Given the Aristotelian connection between agency and reflexivity, one can also construe the duality able/happen as is a voluntary/involuntary pair of reflexive causation: one who does something by itself voluntarily is able to do (what he wants), where one who does something by itself without wanting it just happens to do it.

---

193 Klaiman glosses in as a first or third person oblique clitic. Could it mean hither?
The *able/happen* modal *ka* also does duty for aspect in Tagalog:

\[ \text{Nakapaglitutá na si Lina. 'Lina has just finished cooking.'} \]
\[ \text{Nakakain ka na ba ng durýán? 'Have you ever eaten durian?'} \]

The interchangeability of a past weak modal with existential perfect use here is an example of the Diodorean chronological interpretation of *possible as some time* (Hintikka 1973).

Recall also the characterisation of control through symmetric ability and freedom through the relation algebraic residual *can do want x can do what x wants*.

For instance, Cupeño, a Uto-Aztec language (Klaiman 1991:134), has (in)transitivising suffixes *ine/yaxe* which appear to change surface arity in triples like *húce skin ‘skin’, húce-ine skin caus ‘take off’, and húce-yaxe skin pass ‘become untied’. In other examples, it is only control properties that appear to change:

\[ \text{Ne?en pisílynen/pisílyneyex I pour caus|pass ‘I poured it out/spilled it out’} \]

This example is naturally paraphrased in English as ‘I made/let it pour out’.

Many Southeast Asian languages have passive-like *submissive or adversative* constructions grammaticalised round a weak ability modal meaning *(must) let or suffer*. Examples are Vietnamese *bi*, Chinese *bèi* and Japanese --*(r)are-- (*Klaiman 1991:143)*.

### Complements and adjuncts

The relativity of the notion of role makes one think again about the distinction between complement and adjunct. The terms complement and adjunct belong to a slot-filler metaphor, where a frame has a number of empty slots filled by complements. The rest are adjoined to it as adjuncts. Given inversion, this imagery breaks, for functor and argument roles can be switched.

For categorial grammar, the difference is that adjuncts are identity functors, while complement functors change event type. Is a path a complement or an adjunct? If space is dense and change continuous, every change entails a path. But by the same principle, every change has any number of paths. This implies that path is an identity functor after all, hence an adjunct. Here paths differ from sources or goals. A change can have many goals, but they have to have a nonempty meet.

One cue of non-complement is optionality. Optionality in fact follows from the categorial grammar definition of adjunct. Compare *walk, go, and leave*. It is not accurate to talk about optional or obligatory arguments here. All three occur alone: *Go! Why did you leave? I like walking*. A clear difference in entailment is that it is possible to walk in place, without going anywhere, whereas one cannot go except from one place to another, and one cannot leave a place without going elsewhere. It is in virtue of this that *go* and *leave* “have” a source and a goal, while *walk* only “has” a location.

I would not want to say that *eat* has an optional object. Formally, optionality is alternation, a disjunctive event type. Fortunately, I don’t have to, for this type of optionality is underspecification: *eat* without object means *eat something*. Which also explains its open aspect.

The slot grammar (arity) metaphor on argument places as gaps waiting for a filler is misleading here, and is better replaced by the Boolean (or unificational) metaphor of overlapping partial descriptions of the same scene, all on a par.

The main thing to remember is the platitude that something is adjunct or complement relative to some event type or other. If events types are polymorphic, there need not be such a thing as the semantic representation of an event type. The distinction between complement and adjunct then shifts equally.

For instance, if a path is inferred from density of space and continuity of movement, does path belong to the semantic representation of *go*? How many paths are there in it? What fits “inside” the representation and what remains “around” it? What is the topology of semantic representations? Are they discrete, do they have insides? Or is there just a huge (neural) (word)net? Semantic representations as complex objects vs. semantic postulates as relations between nodes is another case of perspective shift.

The conclusion round the corner here is that there is no call for notions of complement/adjunct or obligatory/optional apart from what follows from a given event type. If you get the event type just right, you predict the participants too.

### Dependents and heads

Once on a destructive course, it is not difficult to buy into another thesis of the radical construction grammar, namely the deconstruction of the definition of a head of a construction. This idea is not foreign to feature based formal grammar. In a feature based grammar, headedness concerns inheritance or sharing of features between a construction and its constituents. The notion of unique head is a simplification afforded by the coincidence of several inheritance principles on one member of a construction. The uniqueness is quite as easily rescinded when different features are distributed on different members.
A reflex of this deconstruction in the event calculus is polymorphism or categorial vagueness. The calculus leaves the operator-operand structure of a construction largely underspecified. For instance, in the verb to object construction, either member can be construed as the functor, or both can be construed as contributing to the construction intersectively.

Uniqueness of roles is better characterised in terms of logic than grammar. A subject is one side of an identity, so two subjects of the same clause must denote the same. Object is a species of subject, so it is subject to the same constraint. Grammatically, this is known as apposition: *My friend, the director, is here or Meet my friend, the director.* Other roles too allow multiple fillers, as long as they have a nonempty meet. It is harder to find examples of asyndetic redescription of event tokens: *They all laughed, downright guffawed, at the show.*

**Diathesis operators**

Lexical argument structure, lexical frames can be modified with morphological derivation and syntax. Diathesis changes, like aspect changes, serve to foreground or background parts of event structure (Pustejovsky 1995). Many aspects are or start out as temporal reflexes of argument structure operators.

Diathesis operators conspire to transform event types so that one of the arguments of the frame ends up in the subject position of the topmost event type of the frame. Logically, such modifications can be represented by argument place permutation, identification and reduction in the style of categorial or combinatory logic (Quine 1966, Curry and Feys 1968, van Benthem 1986:59). Argument abstraction is a way of formalising different perspectives on the same event type. The argument abstracted over is what the predicate is about, and the rest is what the event type says about it. Subject choice is thus a case of perspective (Dik 1978:76, 1989:226, Langacker 1987, 19990, Lapolla/Van Valin 1997:226).

As the subject of a monadic subject-predicate clause, grammatical subject tends to be morphologically unmarked. As a member of the topmost event type, subject is accessible to variable identifications and argument reductions (e.g. binding, anaphora and coordination reduction). These properties are used to test for subjecthood.

In the present context, it is natural to represent diathesis operators in the same way as aspect operators, through regular transduction. A diathesis operator takes an argument frame and transforms it into another frame. Again my belief is that a relatively small number of operators account for a bewildering variety of argument structure alternations in natural languages, when the alternations are stripped to their bare bones. Just as aspects, diathesis operators get coded in lexical, derivation, or inflection morphology or as syntactic constructions.

Diathesis operators form a combinatory logic, allowing elimination (and creation) of variables using variable permutation and binding operators like *inc, caus, refl, pass or do.* They shuffle arguments around as in

\[
\begin{align*}
x \text{ become } p & \text{ equals } \text{inc } p \ x \\
x \text{ cause } y \ p & \text{ equals } x \text{ caus } p \ y \\
x \text{ cause } x \text{ cause } p & \text{ equals } x \text{ refl cause } p \text{ equals } x \text{ do } p
\end{align*}
\]

converting a ‘configurational’ frame to a ‘morphology true’ variant. Reduction laws in relation algebra and other simplicity comparisons help explain why just these argument reducing operations should appear in natural language (van Benthem 1986:59).

Again, my purpose here is not to announce new facts, but try to organise and simplify received ones by subsuming them under uniform treatment. For instance, there is a strong connection between inchoative, passive, reflexive, and diathesis. Finnish morpheme -U- appears in all three roles; *tumma/tumn-U-a ‘dark/darken’, vaihtaa/vaiht-U-a ‘change(tr)/change(itr)’, käänää/käänt-U-ä ‘turn(tr)/turn(itr).*

The category theoretic approach suggests taking event structure apart at the seams, projecting out each subsystem separately, and multiplying the complexity back in to reconstruct the entire spectrum.

One explanatory reduction is obtained from logic of causation. The following identities hold by the definition of cause:

\[
e \text{ cause } e = 1 \text{ cause } e = e
\]

Substituting an intransitive event type \(xp\) for \(e\) we get the equivalence of reflexive causative, passive, and intransitive.

Another morphism is this one. Reflexive commutes with passive through a game theoretical duality. \(x \text{ beats } y\) means \(x\) causes \(y\) to be beaten (\(x\) has a strategy to bring it about). By duality, then, \(y\) lets himself be beaten (has no strategy to prevent it). Here the subject does not act but suffers.

**Inversion**

Inversion *inv* is the binary instance CI of the commutative combinator *C* which swaps positions.

\[
\text{inv } yx: xy
\]
This makes the inversion operator self-dual, i.e. \( \text{inv} \; \text{inv} \; \text{e} = \text{e} \). Symmetric relations are also their own inverses, so \( \text{inv} \; \text{at} = \text{at} \), \( \text{inv} \; \text{with} = \text{with} \), while \( \text{inv} \; \text{in} = \text{around} \). The abstraction operator : and be are inverses salva veritate, for \( \text{x be x}: \text{e} \) is equivalent to \( \text{e} \). They denote different events: the former denotes a state be, while e may be of any event type.

Subject-predicate inversion \( \text{y be x}: \text{x be y} \) inverts the roles of subject and object, type theoretically raising the type of the subject two stories up. This is the Leibnizian representation of an object by the set of all of its properties exploited by Montague and generalized quantification theory.

An example of oblique or locative inversion is the dative alternation exemplified in English by give something to someone / give someone something. The frame \( \text{cause x become with y} \) alternates with \( \text{cause y become with x} \). – to make something go to (become be with) someone is to make someone have/get something. It has been claimed that an unmarked word order \( \text{give y z} \) is more commonly understood as \( \text{cause y have z} \) than \( \text{cause y to z} \) in languages (Givón 1984, Pinker 1989, Drodz/de Weijer (1997). In English, dative alternation produces an unmarked oblique ‘second object’ (give, teach), or a marked oblique (teach someone in something).

The causative of locative inversion creates an alternation between \( \text{cause x be at y} \) and \( \text{cause y be at x} \). Such have been studied in Levin (1989), who divides verbs that participate in it into classes exemplified by spray/load, sow, clear, strip, brush, wipe. These are verbs of contact and separation based on symmetric relations. For instance \( \text{sprinkle x on/with y} \) means \( \text{match surface of x on/with surface of y} \) and \( \text{pack x in/with y} \) means \( \text{fit volume of x in/with volume of y} \) (Tenny 1994:49). Because of the symmetry, the homeomorphism exists between the two arguments \( x \) and \( y \). Causing a change in one term causes a change in the other, so either one can become the object of \( \text{cause} \) (Tenny 1994:53). For instance, in the alternation load hay on cart/load cart with hay (Tenny 1994) the load constitutes a point of symmetry: as hay goes into the load the load gets on the cart.

This observation explains Tennys (1994) puzzle why \( \text{pour coffee into cup/*pour cup with coffee} \) does not invert. \( \text{Pour} \) is not causally symmetric about \( \text{cup} \) and \( \text{coffee} \), for it entails no change in the cup. \( \text{Stuff, pack, or cram are, and invert} \).

Similar comments apply to the complementary puzzle \( \text{fill cup with coffee/*fill coffee into cup} \). Filling is not symmetric either, so what happens to the coffee remains obscure. Again, the result improves with \( \text{fill in name on form/fill in form with name} \).

Parsons (1990) discusses a curious constraint concerning \( \text{empty water from tank/empty tank of water} \) noticed by Dowty: one does not say \( \text{empty tank of water into the sink} \). The intransitive version of the puzzle below shows that this does not depend on causativity.

\[
\begin{align*}
\text{tank empties of water} & \quad \text{tank become tank \neg have water} \\
\text{tank empties into sink} & \quad \text{tank become water in \neg tank \neg sink} \\
?\text{tank empties of water into sink} & \quad \text{tank become tank \neg have water \neg water in \neg tank \neg sink}
\end{align*}
\]

In my analysis, this is a perspective conflict. In the first sentence, the subject of the change is the tank, in the second, it is water. The third sentence tries to have both. The conflict goes away with \( \text{leak} \), where \( \text{water} \) is a direct object and the subject of both changes.

\[
\begin{align*}
\text{tank leaks water} & \quad \text{tank let water become \neg in tank} \\
\text{tank leaks into sink} & \quad \text{tank let water become in \neg tank \neg sink} \\
\text{tank leaks water into sink} & \quad \text{tank let water become in \neg tank \neg sink}
\end{align*}
\]

Another case of symmetric subject-predicate inversion is part-whole alternation: \( \text{kiss cheek on x converts with kiss x on cheek} \). Tenny (1994) notes that this alternation is limited to contact verbs (\( \text{tap, touch, kiss, poke, hit, hurt, wound} \)). Contact verbs hold of a whole iff they hold of a part (there is an implicit existential quantifier in them): \( \text{touch one equals touch one somewhere} \). Not so with \( \text{break or wash} \).

Both conversions are involved in \( \text{stick knife in back on victim/stick victim's back with knife/stick victim in back with knife} \). Compare also \( \text{hit stick against fence and hit fence with stick} \). This can be unraveled as follows.

\[
\begin{align*}
y \text{ hit } z = y \text{ hit against } z \\
x \text{ cause } y \text{ hit against } z = x \text{ cause } y \text{ against } z \quad \text{z = x cause } 1 \text{ against } z \text{ with } y
\end{align*}
\]

Note also intransitive means-ends conversions like \( \text{Ice sparkled in the branches/the branches sparkled with ice, which is an instrumental passive of ice made the branches sparkle} \).

One typologically significant case of subject-predicate inversion has been already mentioned:

\[
\begin{align*}
\text{x be at y} & \quad \text{y have b}
\end{align*}
\]
Given an event calculus, it is possible to compare alternative representations of event types. Below are two for *Tom took the knife from the prisoner*. The first one is a recast of Lapolla/Van Valin’s decomposition (1997:109), the other one of its many images under inversions.

\[
\begin{align*}
\text{(tom do p) cause become (not prisoner have knife) . become (tom have knife)} \\
\text{(tom cause tom cause) (knife be at prisoner) . (knife be not at prisoner)}
\end{align*}
\]

The first one is stronger by implying that Tom gets the knife. That is a likely scenario for concrete instances of *take*, but is less apt for *Tom took his own life*. Both can be accommodated by a representation where Tom having the knife is an interim event (perhaps both, or neither, have it for a moment), and the final outcome is the prisoner losing it.

**Causative**

A causative *event type* is an event type of form \( e \) cause \( e \). A causative *transformation* is a rule which takes event type \( e \) and converts it into event type \( e \) cause \( e \).

\[
x \text{ cause } e : e
\]

Finally \( \text{caus} \) is the causative *combinator* (causative verb morphology, that is) defined by

\[
x \text{ caus } q \ y = x \ p \ \text{cause } y \ q
\]

The difference between caus and cause is grammatical type: cause is a relation, or infix operator between two event types. caus operates on the event type \( p \) and passes arguments \( x,y \) to the outcome. Causative may be thus defined as an operator which adds a cause to an event. Its inverse is the passive combinator pass:

\[
\text{pass } e \text{ cause } e = \text{pass caus } e = e
\]

The dual let for cause as a diathesis operator is called aptative apt. I won’t introduce new abbreviations for the passive of cause corresponding to temporal relations belbecome and the corresponding combinator inc. For instance, be/become old and be caused to be/become old comes out to just the same on both articulations, for be equals I cause be.

The derivation of transitives with a causative combinator caus must be one of the commonest diathesis changes, as also its inverse pass. As both processes are common, the question often arises which is the chicken and which the egg: is the transitive event type basic and the causative an addition. But morphological evidence may go either way. For instance, Chocho is a prefixal language where verb morphology is the exact mirror image of suffixal languages:

\[
d-\text{i?nà má } \text{pres buy I } ‘\text{I am bought.}’ \\
d-e-\text{i?nà má ri } \text{pres caus buy I he } ‘\text{He buys me.}’
\]

Note that the morphologically unmarked event type for of the verb root buy is passive. To respect morphology here, we should really gloss the verb root for buying in Chocho as become bought. Languages of this type are called active-stative (Klaiman 1991:128).

**Manner causative**

Manner causatives are productively formed transitives out of intransitives. Causative-inchoatives have the form \( p \) cause \( q \), where the intransitive becomes the effect \( q \). In a manner causative, the intransitive becomes the cause \( p \) with the addition of an effect \( q \). Examples:

- Väinämöinen lauloi Joukahaisen suohon ‘V. sang J. into a bog’.
- Hevonen juoksi seipään mahaansa. ‘The horse ran a pole into its belly.’
- Syö aivosi virkeiksi. ‘Eat (so that) your brain (becomes) alert’ (TIEDE 2000 1/00)

The paraphrase: Väinämöinen chanted so that Joukahainen sank into the bog, or Väinämöinen sank Joukahainen into the bog by chanting. The above example Sue danced Bill across the room just might have this reading too, but then it won’t imply that Sue moved across the room. The Finnish translations would be different too. The causative reading needs a causative verb Sue tanssitti Billin huoneen poikki, the manner causative keeps the intransitive verb Sue tanssi Billin huoneen poikki.

Tenny (1994:78) suggests that a manner causative like push a car to the garage stays intransitive, analogous to push a car all the way to the garage. This is slightly misleading. The latter construction would let someone ineffectually push a car while he (or something else) gets to the garage (where all the way to the garage is a time adverb). Finnish object marking actually distinguishes this case from the proper movement causative push, where it is the car that gets to the garage by pushing:
Joku työnsi auton talliin. 'Someone pushed the car (acc) to the garage.'
Joku työnsi autoa talliin saakka. 'Someone pushed the car (ptv) until the garage.'

The valid point of Tenny's observation is that push is a process accomplishment and needs a result clause to be aspectually closed (to the garage, flat).

**Factitive**

Factitive refers to higher powers of cause. Factitives are typically, if not exclusively iterations of agentive causation: make/have/let someone do something. A difference between factitive and a mere iterrated causative is that the undertaker is also an agent (McCawley 1976). One who undertakes to do something agrees to do it (for a price perhaps), one who is made to do something does it whether he wants it or not. As a consequence, the undertaker also remains responsible for his part while the commissioner answers for the grand plan.

A range of observations about factitives suggests a possible universal. It is that an unmarked factitive type applies to a passive event type. An iteration of cause is separated by an intervening passive. Given my analysis of passive as a causal specialisation of become, this universal makes factitive an instance of the cause become schema.

There is evidence for the idea. A key observation is that the object of the factitive is the object of the causative, not the subject, and the causative subject becomes an oblique. This type of factitive is represented as the combinator

\[ \text{fact} \quad \text{caus} \quad \text{pass} \]

For instance if feed is fact eat, then x fact eat z by y equals x caus pass r z by y equals x cause z pass eat by y equals x cause y eat z.

There is a passive factitive in English I have my car fixed. This is not just an aspect of I fix the car, for it does not entail I fix the car. It is a factitive causative I have somebody fix my car with a passive complement clause. This type of a passive factitive is represented by

\[ x \text{ get } y \text{ done by } z \]

which ought to be equivalent to x cause z do y to z or x cause z do y to z depending on whether get is agentive. And so it is, for we have the following derivation for it from diathesis definitions:

\[
\begin{align*}
\text{x get y done by z} \\
\text{x get } \land \text{ y be done } \land \text{ z < } \\
\text{x < x } \land \text{ do } \land \text{ y } \land \text{ z < } \\
\text{x < z do y < x} \\
\text{x cause z do y to x}
\end{align*}
\]

A two-agent factitive is thus the causative of an agentive passive. The subject is an agent who gets something done by another agent acting as a middleman or instrument. The causative have is an acquisition vague between an event causative I get my car fixed and a result causative I've got my car fixed. The latter is an obvious source of have plus passive perfect participle type perfects. If we identify i with x in the above, we get I've got my car fixed by myself which means I have fixed the car.

The weak modal let in place of cause gives a benefactive or adversative I let fix my car. Argument inversion gives The car was fixed for me by them.

Bulgarian has a have Ved construction with analogous meanings. imam gi napecatani can mean 'I have printed them', 'I have had them printed', and 'I have them printed' (Lindstedt 1985:69).

Case markings in French and Finnish causatives and factitives are strikingly similar.

La maman fait manger les enfants. Äiti syöttää lapset (acc). 'Mother feeds the children.'
La maman fait manger les pommes aux enfants. Äiti syöttää omenat lapsille (all). 'Mother feeds the apples to the children.'
La maman fait manger les pommes aux enfants par le papa. Äiti syöttää omenat lapsille (all) isällä (ade). 'Mother lets father feed the apples to the children.'

Allative is the dative (animate goal) case, adessive the instrumental case in Finnish. The case markings follow from the hypothesis that the structure of these factitives is not x cause y cause z p, but rather causative passive x cause z become p by|to x. For then the logical forms of the above French and Finnish sentences can be literally cause x eat, cause y become eaten to x, cause z become eaten to x by y. The cases, when written out, match goal and path roles in the frame as expected.

In a cause become type factitive chain causatives and passives form alternating sequences. Finnish factitives obey the constraint. The causative of ajaa 'drive' is ajattaa 'make drive', whose factitive is ajattattaa 'make driven by someone',
which has a reflexive-passive morpheme $u$ in the middle: $aja$-$tta$-$u$-$tta$. A dual of this is $aja$-$tta$-$u$-$tta$. Here is another example:

\[
\begin{align*}
erota & \ 'be(come) separate, resign' \quad & \text{change of} & \quad eri \ 'different' \\
erottaa & \ 'separate, distinguish, dismiss' \quad & \text{causative of} & \quad erota \\
erottaa & \ 'be(come) distinguished, separated' \quad & \text{passive of} & \quad erottaa \\
erottautaa & \ 'get oneself separated' \quad & \text{reflexive of} & \quad erottaa \\
erottuttaa & \ 'make someone separate something' \quad & \text{factitive of} & \quad erottaa
\end{align*}
\]

The universal also seems to explain the “problem of the disappearing pag” in Tagalog, as well as the “mysterious morpheme” $pa$ observed to appear between two causatives in Travis (2000:158,165), as well as the analogous mystery of a reflexive $u$ between two causatives in Finnish (Karlsson 1982:240).

The implicit middle term of the factitive construction can also be cancelled by construing a factitive as the relation algebra composition \(\text{cause.cause}\) or \(\text{cause}^2\). By reflexivity and transitivity of causation, \(\text{cause}\) is idempotent, i.e. \(\text{cause} = \text{cause.cause} = \text{cause}^*\). This suggests another universal of factitives: the number of semantically distinct powers of \(\text{cause}\) is rarely higher than one or two, and related to the ability of the language to denote oblique agents. The first power of \(\text{cause}\) is a transitive verb. The second power is the factitive. For instance, Finnish \(\text{marssia}\) ‘march’ occurs in three constructions:

Sotilaat \(\text{marssivat}\). The soldiers marched.
Kersantti \(\text{marssitti}\) sotilaita The sergeant marched the soldiers.
Kuningas \(\text{marssitutti/marssitti}\) armeijoitansa kenraaleillaan. The king marched his armies by his generals.

The opposition between single and double causative verbs \(\text{marssitaa/marssittaa}\) is not systematic, they appear in free variation. This speaks for the transitivity universal just proposed.

The unmarked passive factitive is not the only event type where an agent gets another to do something. Sight unseen, on the basis of English paraphrases only, there are several event types to grammaticalise into a factitive:

- Have something done by someone (passive factitive)
- Have someone doing something (antipassive factitive)
- Give something to someone to do (dative factitive)
- Put (get, let) someone into doing something (illative factitive)

For instance the applicative causative of Fula falls under this generalisation. It turns the subject of the effect into object. Note the direct word order of the applicative causative and the meaning of its passive. It is represented by \(\text{caus}\), or \(\text{fact act}\).

\[
\begin{align*}
\text{Puccu yarnii ndiyam \ horse drink water} & \ 'The horse drank water' \\
'o yarnii puccu ndiyam \ he drink cause horse water' & \ 'He let the horse drink water.' \\
\text{puccu yarnaama ndiyam \ horse drink cause pass water} & \ 'The horse was allowed to drink water.' \\
\text{ndiyam yarnaama puccu \ water drink cause pass water} & \ 'Water was allowed to drink the horse.'
\end{align*}
\]

Judging from the morphology, the weak-strong or “self-act” versus “other-act” voice distinction in Tamil (Klaiman 1991) could involve causative and factitive. Intransitive strong forms are unaccusative (passive intransitive), weak forms are unergative (medial), while transitive strong forms carry an extra causative morpheme /t/. See the section on Tamil.

The French and Thai factitives are of the dative type.

**Adversative**

In a factitive reflexive the subject causes another agent to cause something for the subject. But also the adversative type where subject \(\text{lets something happen to the subject.}\)

\[
\begin{align*}
\text{ru Parikmakher pobril jegu / on pobrilsja u parikmakhera.} & \ 'The barber shaved him / He got himself shaved at the barber's' \\
\text{lt Atsakymas patenkino mane / Ash pasitenkinau atsakymu} & \ 'The answer satisfied me / I contented myself with the answer'. \\
\text{lt Mane zhavi muzika / Ash zhaviuosi muzika} & \ 'Music charms me / I am charmed by the music'
\end{align*}
\]

A closely related type is a dispositional ergative intransitive
Factitive reflexive is a source for relation converses. This includes reflexive agent passive, described in the next section, and cases like

It Petras paskolino man pinigum / Ash pasiskolinau ish petro pinigum ‘Peter lent me money / I borrowed money from Peter.’

Path as object
It is a typological universal that an intransitive verb can have a path in the grammatical role of a direct object in the style of

John ran the way from home to school.
John juoksi matkan kotoa kouluun.

In what sense is the way an object of ran here? We may try to place it in the appropriate position in the transitive schema to find out.

j run cause j at home. j on way . j at school

By my definition of direct object, the path ought to be the subject of a change brought about by the run. What change? This calls for predicate-argument conversion. While John changes from being at home to being at school, the way changes from taking John from home to leaving him at school:

j run cause way be j on way). on(j,way),on(j,way`school).

This analysis does not rule out the possibility of two objects framing one and the same event:

John talutti pyöränsä mailin. 'John walked his bike a mile.'
John talutti pyörä(ä)nsä kotiin. 'John walked/was walking his bike home.'

As expected, the direct object is an affected object, and appears in the partitive case in Finnish. Contrast this with a sentence with a goal adjunct, where the direct object shows aspect. Tenny (1994) reports that path objects like climb a mountain form process accomplishments in English.

Voice
Voice, widely understood, concerns the marking of roles in grammar; narrowly, the marking of subject in verb morphology (Klaiman 1991).

Role marking can be based on word order, subject-predicate abstraction, locative cases, person, number and gender marking, other noun classifiers, animacy hierarchy, or information structure.

Klaiman (1991) develops a notion of basic voice defined by semantic features rather than argument structure. Klaiman is right in that voice involves more than argument linking. In particular, control features translate to grammaticalised ability type modalities. See section on control.

Grammatical subject has been characterised as a locus of neutralisation between the notions of agent and topic (Li and Thompson 1976:484, Keenan 1976, Plank 1979:15). Grammaticalisation of subject shows in case marking, agreement, and argument binding (control and anaphora). Typologists distinguish language types by subject marking over four types of argument frames. (The distinction between agentive and plain causative transitives is not made here.)

<table>
<thead>
<tr>
<th>x cause y p</th>
<th>transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>x cause x p</td>
<td>unergative</td>
</tr>
<tr>
<td>&lt; cause x p</td>
<td>unaccusative</td>
</tr>
<tr>
<td>x p</td>
<td>intransitive</td>
</tr>
</tbody>
</table>

These four types form a fourfield with presence of agent or patient as axes:

<table>
<thead>
<tr>
<th>patient/agent</th>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>transitive</td>
<td>unaccusative</td>
</tr>
</tbody>
</table>
The now traditional typology (Comrie 1978, Dixon 1979, Plank 1979, Klaiman 1991, Lapolla/Van Valin 1997:282) is to distinguish three major language types according how the fourfield of roles is marked.

In the agentive (or active) type argument marking is by agent role. The fourfield is split vertically. For instance Lakhota and Central Pomo have different personal pronoun forms for unergative and unaccusative intransitives (Croft 2001, Van Valin 1990, Ritter/Rosen 2000).

In the accusative type, the prefix of the causal chain is made subject. The suffix if any is marked with accusative case. Accusativity is the most familiar (and widespread) type. Accusative cases are etymologically derived from markers of goals. Voice does not mark role.

In the ergative type, the suffix of the causal chain becomes subject irrespective of role. The prefix if any is marked with ergative case. Ergativity has the feel of unmarked passive or medial diathesis. Ergative cases are etymologically derived from markers of source, instrument and possession.

This typology may have caused more trouble than it is worth. Ergative-accusative splits between morphology and grammar, open and closed aspect, or person and number agreement always leave “some accusativity” in ergative languages.

Ritter/Rosen (2000) propose a dichotomy of languages that divides the above fourfield between the two columns. On the left side are agentive languages, called I-languages for their attention to the beginning of the causal chain (the agent or first cause). I-languages are sensitive to agentivity and animacy, have many grammatical voices, and split the Vendler fourfield along the state-process boundary, grouping activities and accomplishments together against states and achievements.

On the right side are accusative languages, called D-languages, focus on the end of the causal chain (the effect or result). They split the Vendler fourfield along the closed-open boundary, pitting achievements and accomplishments against states and activities. They are sensitive to referential properties of the object (but not object person), shown in object case marking.

Ergative languages in this binary typology get split between the camps, into agentive-ergative languages which do ergative splits on animacy, and accusative-ergative languages which split on aspect.

One language’s voice is another language’s person, depending on where arguments are marked.

Third person singular inanimate

This is the unnamed third person singular “impersonal” person, or singular inanimate formal person it or place there. Impersonal construes the world as a whole (though maybe only a small world, like the French tout le monde) as a subject. Interestingly, it is not just a metaphor, but makes good formal sense too. A formal subject it is formal by all means, but it can still denote the unit of a suitable relation algebra. This covers the so called formal subjects of impersonal event types like weather verbs, emotion causatives etc, but is restricted to human agency in personal event types (Genusiene 1987:278).

\[
\begin{align*}
\text{lt} & \quad \text{ten vaikai zhaidzha / ten (vaikum) zhaidzham} \ 'There children play / there is playing (of/by children) \\
\text{mc} & \quad \text{Vo salata tancuva mladina / vo salata se tancuva} \ 'In the hall dances / youth / In the hall it dances itself' \\
\text{lt} & \quad \text{Ten dainuojama.} \ 'There is singing there.'
\end{align*}
\]

In impersonal passive the object stays object, the subject is 1, the agent if any is an instrument or source. The impersonal “somebody does and it is a” passive reflects a relation algebraic truth

\[
\text{arb} = \text{1rbf} \land x=1 \leftrightarrow \text{xc} \land x=a
\]

\[
\begin{align*}
\text{ir} & \quad \text{fèi lladdod ddraig / fèi lladdwyd gan ddraig} \ 'him killed dragon / him it killed by dragon' \\
\text{la} & \quad \text{Boni cives legibus parent / Legibus (a bonis civibus) paretur} \ 'good citizens obey to laws / to laws is obeyed (by good citizens)' \\
\text{pl} & \quad \text{Mojego kolegem goli siem v domu} \ 'It shaved itself my colleague at home' \\
\text{sv} & \quad \text{Det byggs hus.} \ 'There is houses built.' \\
\text{es} & \quad \text{Se vende los libros} \ 'They sell books'. \ 'Se vive bien aqui. \ 'One lives well here.' \\
\text{pt} & \quad \text{Vende-se estas casas.} \ 'These houses are sold / on sale'
\end{align*}
\]

The Spanish reflexive passive belongs formally here, for the number of the verb is singular and the object stays an object. Insofar as the agent is animate, it borders on the next type.
Third person plural animate

This is the “fourth person”, or plural animate unspecified subject they. It is left cancellation (right projection) of an agentive event type, so the cancelled subject I denotes third person plural unnamed agents. The deed can in practice be done by one person, but the implication is to ‘a party’, like a coalition or society.

1 cause 1 call x

pl Petra kviechia im dekanatam ‘They summoned Peter to the dean's office.’
fi Petteri kutsuttii kansliaan. ‘Peter was summoned to the office.’
de Man hat Peter zur Kanzlei rufen lassen. ‘Peter was summoned to the office.’
fr On a appelé Pierre au bureau. ‘Peter was summoned to the office.’
ru Petra kazali v bjuro. ‘They summoned Peter to the office.’
fi Lähdetään! fr On y va! de Geh man! ‘Let’s go!’

An inanimate subject won’t do here, even if the verb allows personifying it:

fi Sade kasteli Petterin. Petteri kastui / kasteltiin sateessa. ‘The rain drenched Peter. Peter was drenched in the rain / they drenched Peter in the rain.’

Reflexive and generic (man, on) impersonal has a tendency to replace first person plural by a process of polite indirection, while third person singular and plural may replace second person. Polish has both reflexive and third person plural impersonals. Apparently the former includes first person and the latter excludes it (Genusiene 1987:280). Related to this is the contrast in German between

Hier wird getanzt ‘They dance here’
Es tanzt sich gut hier ‘This is a good place to dance’.

The third person plural can point to an event token, the reflexive is dispositional generic. Gut cannot be left out. (Genusiene 1987:288) Compare English this place lends itself to dancing. Recall that ability is an inherently reflexive modality (x can p = 1 let x cause x p).

Reflexive

Reflexive refl instantiates the combinator W which identifies positions. A reflexive pronoun can be construed as a postfix reflexive combinator: x kill self = x kill x.

refl x e x: e x

The causal chain allows distinguishing several forms of reflexive diathesis, depending on which positions are identified (Barber 1975, Haiman 1976, Genusiene 1987):

x cause y cause z cause w

Identification of x and y gives an agentive do or refl cause cause. Reflexivity here entails that an agent acts by itself as well as on itself. Identification of y and z gives a plain object reflexive refl cause like kick oneself. Putting both together produces an agentive reflexive refl cause refl cause like stand up. Identification of y and w gives an oblique reflexive like make oneself a sandwich.

Here are some of the frames to distinguish (there are more, given factitives). The terms on the right are only suggestive.

y cause y cause x p        agentive (nonreflexive) transitive
x cause x cause x p        agentive reflexive (unergative)
y cause x p                (causative) transitive
x cause x p                (causative) reflexive
1 cause x p               passive intransitive (unaccusative)
x p                       intransitive (stative or inchoative)

For instance, It Durys atsidare ‘The door opened’ may be understood in three ways: somebody opened the door, the door opened because of the wind, or the door opened by itself (Genusiene 1987:100).

Reflexive and passive are produce inverses of causative. The intuitive interpretation of the relevant principle of the logic of causation is that an event caused by everything in general, or by nothing in particular happens by itself, is not caused at all. Autocausative becomes decausative (Genusiene 1987).

An intriguing observation is that in many cases reflexives and causatives also coincide. There is no difference between a reflexive in one language and a causative in another. This too goes back to the logical properties of causation. A first cause is one whose only cause is itself. Conversely, an event which is caused by another must let this happen to itself.
Object reflexive

This is the case where subject and object coincide. Most cases are entirely routine. Genusiene (1987:88) makes note that many reflexive event types denoting body motion exclude instruments: it does not sound sensible to throw oneself forward or press oneself against someone with something. Note that these cases typically go into intransitives in English (press against someone, hide somewhere).

ru Odejal nakryl ee / Ona nakryla ego odejalom / Ona nakryla's odejalom 'The blanket covered her / She covered him with the blanket / She covered herself with the blanket'
ru On brosil kamen / On brosilsja vprered. ‘He threw a stone / He threw himself forward’
lt Jis sedo(si) prie stalo He sat (himself) down at the table.

Note the idempotence of reflexive for the dynamic state  sit due to its inherently reflexive diathesis  x sit = x cause x sit. Object reflexives include the typologically very common case of part reflexives.

ru Oda prishchurila glaza / ona prishchurilas 'She screwed up her eyes / she squinted'
lv Jis uzhmerke akis / Jo akys uzhimerke / Jis uzhimerke 'She screwed up her eyes / she squinted herself with eyes / she squinted’
lv Ille emungit nares / Ille emungit se 'He blows his nose / he blows himself’
sv Han snyter násan / han snyter sig ‘He blows his nose / he blows himself’
fi Hän niistää nenänsä / hän niistää ‘He blows his nose / he blows’
al Ai kreh floket / Ai krihet ‘He combs his hair / He combs’
bg Toj porjaza prusta / toj se porjaza 'He cut his finger / he cut himself (in the finger)’.
mo El increteste fruntea / el se increteste ‘He knits his brow / he frowned’

Part reflexives would not deserve a separate name if they weren’t so common. There is not much to explain here. Existential event types are closed under extension of the domain, so I touch myself if and only if I touch myself somewhere. In these cases too English and Finnish use transitive verbs intransitively, taking advantage of the relation algebraic equivalence  x=1 → xrx = xr.

Reflexive manner causative

Here the subject causes a change to itself by doing something. The cause is a one place open event type, the change a one-place closed event type. Grammatically, the it may count as a free standing predicate complement or goal adverb (many a “verb prefix” is an affixed goal adverb).

x p cause x q

This is nothing but a reflexive instance of the manner causative construction. It is an exceedingly common productive construction in languages: en work oneself free, lit ishisverkti ‘cry oneself out’, nodejoties ‘dance one’s fill’. fi ikeä itsensä uneen ‘cry oneself to sleep’, juoda itsensä kuoliakasi ‘drink oneself dead’ (Genusiene 1987:214). The effect is usually a half-closed event type, but cycles are found too: lit chiaudeti ‘sneeze’ nu-si-chiaudeti ‘give a sneeze’ (Genusiene 1987:§2.1.5, §4.2.3.2.1).

Agentive reflexive

An agentive analogue of causative-passive alternation is the agentive reflexive alternation wash one / oneself, or more appropriately, get (oneself) washed, or even factitive let oneself get washed:

ru myt’sja ‘get washed, wash oneself’. agentive reflexive of myt ‘wash’
fi pese-yty-ä ‘get washed, wash oneself’ agentive reflexive of peste ‘wash’
en wash (oneself) agentive reflexive of wash

Finnish agentive reflexive derivative affix  U-T-U consists of a causative TA sandwiched between two reflexive or passive U affixes. This peculiarity is explained in the section on factitives (for a second opinion, Hakulinen 1967:230). Genusiene (1987:191-2) points out that English medial intransitive wash is not synonymous with the reflexive wash oneself, but rather to get washed:

The child is old enough to wash (?herself).
I want to wash the child but she does not want to wash (?herself).

There is a similar contrast between prove (oneself) guilty. On the other hand, compare hurt oneself and get hurt. Neither entails agency, but there is a difference in attribution of responsibility. One can get hurt by someone else, but can’t very well hurt oneself on someone else.
Dispositional reflexive

An interesting phenomenon, related to the classical middle voice, is that reflexive diathesis can turn a transitive accomplishment into an intransitive activity, habit or disposition (Melchuck 1993:§7.3). Russian *rugat‘*scold someone‘* rugat‘sja ‘complain’, *kusat‘*bite something*, *kusat‘sja ‘have a tendency to bite*. Here the reflexive argument is not a direct object but fills some oblique role (e.g. complain for oneself). The aspectually open dispositional type best understood as causation of a quality by another: dog p cause dog bite 1 i.e. some quality of the dog causes it to be such that it bites (people). The English *The book sells well* is a reflexive generic passive: book p cause 1 sell book well i.e. some quality of the book causes the quality of its sales.

What is dispositional reflexive? "the dog bites anyone", "the dog bites of itself". It is agentive passive-reflexive plus universal antipassive. It is like an animate in that it needs no outer cause. But the action is not planned or controlled by the dog either, it is in its nature, it can't help itself. And it bites most anyone in reach, not just someone, the object is generic. Finnish and English again use the verb intransitively.

<table>
<thead>
<tr>
<th>Language</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>bg</td>
<td>Kot dzjare kago-nebudz / Kot dzjarecca ‘The cat bites anyone / the cat bites out of its own nature’</td>
</tr>
<tr>
<td>bg</td>
<td>Vsetkych bije / on sa bije ‘He fights anyone / he fights just like that’</td>
</tr>
<tr>
<td>bg</td>
<td>Toj buta vsichki / toj se buta ‘He pushes everybody / he is pushy’</td>
</tr>
<tr>
<td>sv</td>
<td>Hunden biter alla / hunden bits ‘The dog bites anyone / the dog bites’</td>
</tr>
<tr>
<td>fi</td>
<td>Koira puree kaikkia / koira puree ‘The dog bites’</td>
</tr>
</tbody>
</table>

All of these should follow from the analysis

**dog cause dog bite 1**

Here dog cause dog is the reflexive bit, and 1 is the antipassive bit. The dog does not bite itself, it bites anyone of itself. Not for itself either, that is the benefactive type. The reflexive concerns the motives, or animate causes – the dog needs no particular motive for biting, it does it just like that. (Motive is final cause, or mind mediated efficient cause).

The absence of an object indicates the object is arbitrary. For further confirmation, Georgian has a generic plural third person object in place (Genusiene 1987:314).

zhaghlı kacs kbens / zhaghlı ikbineba ‘The dog bites a man / the dog bites itself them’

Where does the genericity come from? Well, what we are saying here is that the dog *is of its nature such that* it bites something whenever there is something to bite. The dispositional whenever clause is what makes the quantification universal and the predication generic. The object of biting is just a boundary condition, not the cause. The cause is the dog itself, the object is just the trigger. The dog being by nature the biting kind, the identity of the object is not the explanatory factor, it is immaterial, arbitrary. So we really have:

**dog cause dog bite x if dog can bite x**

The dog bites whatever it can. Which means that the dog wants to bite, because want can be defined as the residual will if can. The aspect is open.

The disposition type and passive reflexive type are related as animate to inanimate. One happens by itself, the other of oneself.

Passive reflexive

A passive reflexive tells an event happens by itself. The reflexive binding is from object to cause. "By itself" means the same thing as "by accident". This comes from the logic of causation. An inanimate cause can be mentioned, like the wind in the Lithuanian example, but a human agent is excluded (Genusiene 1987:100).

lt Vejas sklaido rukam / Rukas sklaidosi nuo vejo ‘The wind is clearing away the fog / The fog clears away with the wind’.
ru On razbil steklo / steklo razbilos‘ ‘He broke the glass / the glass broke (by itself)’

1 cause x cause p = 1 cause p by x = 1 cause p by 1

Apparently, Spanish makes a distinction between intransitive morir ‘die’ and morirse ‘die by natural causes’, i.e. die on one’s own (Genusiene 1987:31).

Passive reflexive reduces to a change or a state depending on aspect (Genusiene 1987:101-102). Full or near synonymy on the identity be|come = refl caus is common (Genusiene 1987:137).

lt Sapes norima(s) ‘The pain subsided (itself).’
lt Oraas kinta / keichiasi ‘The weather changed / changed itself’
fi Himmat aelenivat / alemuivat ‘The prices lowered (inchoative) / got lowered (causative-reflexive)’
Similarly, \textit{lt krist} ‘lower’ = \textit{kristies} ‘get lowered’

Comparing English reflexives to Baltic ones, Genusiene notes English does not exhibit the following reflexive types:

- the dog bites (of) itself
- the girls kissed (between) themselves
- Peter kisses (himself) with Ann
- he caught (himself) at the machine.
- this cloth washes (itself) well
- the pencil broke (by) itself
- the trees reflect (themselves) in the lake
- I shaved (myself) at the barber’s

From my vantage point, these are all passive reflexives. English reflexives are active. Whenever the meaning is passive or adversative meaning \textit{V of/by itself, get oneself Ved, or let oneself be Ved}, English uses passive or medial intransitive forms instead. Compare \textit{Peter lays / gets laid with Ann}.

\textbf{Emotion causative}

Emotion causative is a special case of passive reflexive (Genusiene 1987:102). In emotion causatives, the inanimate source of a feeling becomes a subject or source or it is left out. The subject of the feeling is an experiencer (animate recipient or goal). The morphology of the verb is causative or reflexive, as could be predicted from the event type:

\begin{align*}
x \text{ want } y &= y \text{ cause } x \text{ want } y \\
x \text{ hear } y &= y \text{ cause } x \text{ hear } y \\
1 \text{ cause } 1 \text{ cause } x \text{ cry} &= 1 \text{ cause } x \text{ cry because } 1 = x \text{ cry because } 1
\end{align*}

\text{ru} Jacho xaboko / Mne xochetxja xaboko ‘I want apples / Apples would be nice’

\text{lt} Ash noriu obuolo / Man norisi obuolo ‘I want an apple / An apple would be nice’

\text{fi} Minä haluan maata / Minua haluttaa maata ‘I want to lie / To lie makes me want’

\text{lt} Ash nedirbu / Man ne sidirba ‘I don’t work / I don’t feel like working’

\text{ru} Ja slysnu muzyk / Mne slxyshija muzyk ‘I hear music / I can hear music (music makes itself heard to me)’

\text{lt} Ash girdzhiu muzika / Man girdisi muzika ‘I hear music / I can hear music (music makes itself heard to me)’

\text{ru} Ja placnu / Mne placxetxja ‘I cry / I feel like crying (something makes me cry)’

\text{fi} Minä itken / Minua itkettää ‘I cry / (It/so) something makes me cry’

Expressing inclination with impersonal (reflexive) causatives is productive in Russian and Finnish. The same form doubles as a regular causative event type \textit{Tapaus itketti meitä} ‘the incident made us cry / feel like crying’. Near synonyms include be (un)able (not), feel like or be(have) as if.

A feature not captured yet is that the emotion causative construction is imperfective. In Finnish, the object stays in the partitive, so there is no telling whether everyone in fact cried. That is expressed by a different construction \textit{tapaus sai meidät itkemään} ‘the incident got us to cry’. What is the \textit{inclination} rather than \textit{change} involved in the emotion causative construction?

Digging deeper, emotion causatives turn out to be image events. Reality \textit{1}, perhaps but not necessarily the real cause \textit{y}, causes an image of \textit{y} in \textit{x}. It is not \textit{y} that comes to \textit{x}, only its image is reflected on \textit{x}. In reality, there may not be any \textit{y} at all.

\textit{1 cause image of \textit{y} in \textit{x}}

Emotion causatives are not event causatives, but state causatives. Something, named or unnamed, causes a mental state, an image of \textit{y}, to obtain or persist in \textit{x}. The causative of open event type \textit{cry} remains open as well.

\textbf{Reciprocal reflexive}

Reciprocal is a common reading of plural reflexives. It has been discussed at length in the section on plurals. Essentially, reciprocal is the irreflexive subset of plural reflexive, the diagonal excluded from the relation.

\text{ru} brat poceloval sestr / brat is sestra pocelovalis’ ‘brother kissed sister / brother and sister kissed (between) themselves’

\textbf{Middle}

Classical languages (Greek and Sanskrit) have a grammaticalised medial diathesis as a middle voice (Kühner 1896:§374, Fillmore 1968:24, Klaiman 1991). Medial verb (form)s include object reflexives like \textit{loouomai} ‘I wash myself’ and
oblique reflexives like ekopsamen ten kephalen ‘Ich schlug mir den Kopf, I hit my head’, paraskeuazomai ti ‘I am preparing something for myself’, where an oblique argument role is bound to the subject. Goal reflexive has been claimed to be the prototype case (Genusiene 1987:290). Klaiman (1991) also notes that a straightforward object reflexive is rather the exception for grammaticalised middle voice. Even louomai can be construed as a possessive reflexive ‘I wash my body’. In a strict sense, then, middle is an oblique reflexive voice. (See section on the typology of reflexives.)

Middle voice turns verbs of external action into verbs of internal reflection: plattein/plasasthai ‘(sich ein)bilden (picture to oneself)’. Plank (1979) argues in effect that English ergative The book sells well is reflexive or medial, assigning the cause of the good sales to the book itself.

The reflexive analysis makes verba activa, or unergative verbs, reflexive (agentive) causative. Klaiman (1991:92) calls this the neuter function of the middle voice. The idea is not new. It is part of the folklore of the classical scholarship on the Greek medial diathesis and Latin verba deponentia, summarised in Kühner (1889:101ff):

Die Medialform bezeichnet erstens eine Thätigkeitsäußerung, welche das Subject an, in oder mit sich selbst vollbringt. … Hier sind zwei Fälle zu unterscheiden. Erstens: die Medialform hat die Eigentliche, reflexive, subjective Bedeutung, indem sie eine innere Thätigkeitsäußerung des Subjekts ausdrückt. Die Thätigkeitsäußerung ist notwendig auf das Subjekt bezogen, so dass das Subjekt von dem Objekte räumlich nicht getrennt ist, sondern mit demselben zusammenfällt. Der Deutsche drückt solche Reflexive durch die Verbindung des Aktivs mit einem unbetonten Reflexivpronomen aus, als: ich freue mich, fürchte mich, oft aber auch durch intransitive Verben. Zu dieser Klasse gehören einige Verben, welche in der Medialform eine innere, Thätigkeitsäußerung ausdrücken, als bouleusasthai, sich beraten (bouleuein inini, einem raten), endlich die sog. Deponentia Medii, von denen viele eine geistige Thätigkeitsäußerung ausdrücken, als: theasasthai schauen...

Zweitens: Die Medialform hat nicht die eigentliche Reflexivbedeutung, sondern bezeichnet die Rückwirkung einer transitiven Thätigkeitsäußerung des Subjektes auf sich, so dass das Subjekt zugleich als thätig und leidend erscheint. Die Thätigkeitsäußerung ist eine solche, welche nicht notwendig, sondern nur zufällig auf das Subjekt zurückbezogen wird, indem das thätige Subjekt von dem die Thätigkeitsäußerung erfahrenden Subjekt räumlich getrennt gedacht werden kann. Solche Medialformen übersetzen wir in der Regel durch transitive Verben mit dem Akkusativ des Reflexivpronomens. Sie bezeichnen meistens äussere Thätigkeitsäußerungen. Es gehören hierher besonders folgende Verben: kopsasthai, tupasasthai, sich schlagen, kupsasthai, sich bücken …

Bei vielen Verben, welche sowohl die aktive als die mediale Form haben, findet ein wichtiger Unterschied der Bedeutung statt, indem die aktive Form eine Thätigkeitsäußerung schlechthin, ohne weiter Nebenbeziehung (objektiv), die mediale Form hingegen dieselbe mit Beziehung auf subjektive Selbstthätigkeit ausdrückt … blakeuomai, ich bin träge, blakesomai, ich zeige, benehme mich träge.

Kühner’s first group are agentive reflexives, the second group causative reflexives. Kühner’s last type bears comparison to the English progressive of state I am being lazy. Both denote an agentive state x do lazy which I analyse as x cause x be lazy. It is this last type that Klaiman (1991:69) calls deponency in reference to Latin verba deponentia which depose their active forms. Such media vel reflexiva tantum are common cross-linguistically in much the same event types across the board (Genusiene 1987:299, 339).

Medial voice is found in other languages around the globe, for instance Fula (Klaiman 1991). The description of meanings of the middle voice in Fula closely matches the classical description quoted above (Klaiman 1991:58).

There is a correlation between middle diathesis and irrealis, including imperfective aspect, counterfactual mood and future tense. There is a connection between reflexive and planning (see section on plans). Another, related one is the connection between reflexive and come (see section on top event types).

For instance, Greek future tense favors the middle voice especially for unergative bodily motion (Klaiman 1991: 96, Smyth 1974:219). So do Fula future and negative inflections (Klaiman 1991:61). Altogether, my version of the reflexive analysis of the middle voice seems to handle Klaiman’s Fula data nicely. For instance, Fula has a nicely regular system:

```
femmb-a shave act ‘shave someone’ x cause x shave y
femmb-o shave mid ‘get oneself shaved’ x cause y shave x
femmb-it-o shave refl mid ‘shave oneself’ x cause x shave x
```

Note how the name medium fits the diathesis here: the agent is not just at the source of the causal chain, but also in the middle of it.

Klaiman’s (1991) analysis of the middle voice sides on a notion of basic voice defined by semantic features rather than argument structure positions. His main argument against the reflexive account is that the middle voice does not always change arity. True, for reflexive binding of noncomplement roles does not. Klaiman seems to be elaborating a
distinction without a difference. Klaiman’s feature of affectedness (“the action or state affects the subject of the verb or his interests”) in effect translates into reflexive binding of a variable path expression matching any oblique reflexive role in an event type. But Klaiman is right in that voice can be coded in ways which do not involve argument structure. In particular, control features translate to grammaticalised ability type modalities. See section on control.

The best argument for the reflexive analysis is that it generates explanations to many puzzles. Impersonal passives like de es wurde getanzt: ‘there was dancing’ are only formed out of unergatives. This has the structure x cause x dance, which passivizes to _ cause _ dance meaning somebody danced. This predicts that impersonal passives are agentive: there is no es wurde geregnet/geweht ‘there was raining/blowing’. Swedish, French, or Finnish impersonal passives det dansadeson a dance/hanssittin act the same.

Another supporting pattern is the use of partitive case on negative existential subjects. In Finnish, Russian, and Basque, partitive marking appears on transitive objects and intransitive subjects, but not on transitive or unergative subjects (Lapolla/Van Valin 1997: 303). In ergative languages, the case marking of causative reflexives varies between agent (ergative) and subject (absolute). This too makes sense if the relevant argument plays both roles at once. There is also the cross-linguistic tendency for future forms to be medial: In the Urbild of modality, futurate modalities are related to planning. To quote Kühner:

Hiermit hängt die merkwürdige Erscheinung zusammen, dass nicht nur die sämtlichen oben genannten, sondern auch viele andere Verba activa ihr Futur mit der medialform bilden, als akouo, akouosomai, ... und zwar sind es vorwiegend Verben, die eine sinnliche oder geistige Thätigkeitsäußerung bezeichnen.

Foley/Van Valin (1984) entertain the idea that agentive intransitives are causative (John run to the store meaning John’s running caused him to get to the store). The idea is rejected in Lapolla/Van Valin (1997:93) on two accounts: a) the definiens has three noun phrases against the two in the definiendum. b) no language they know use causative morphology to express agentive intransitives.

Both problems are solved by the reflexive causative analysis. The reflexive removes the extra argument added by the causative. There are agentive intransitives with reflexive causative (medial) morphology in many languages, for instance fi istuutua ‘sit down’ from istua ‘sit’, Greek medial histamai ‘stop’ from stenai ‘stand’. Klaiman (1991:31) criticises Barber’s (1975) reflexive analysis of the middle voice for missing the unaccusative or accidental meaning of Sanskrit namate dandah bend mid stick ‘the stick bends’. I catch it as stick let stick bend. In an oblique reflexive some other role than object is bound. One instance is dative or benefactive reflexive (Genusiene 1987:72).

1v Jis pri(s)jaukino lapem ‘He has tamed (himself) a fox’
1t As skelbiu Baltinius vaik’ams / As skalbiuos Baltinius. ‘I wash linen for children / I wash my linen.’
1t Zita prausia(si) veidam. ‘Zita washed her face’
1t Petras in(s)kvepė oro ‘Peter inhaled (himself) some air’
1t Jonas atsivezhe (*man) knygam ish Moskvos ‘Jonas brought himself /me a book from Moscow’

Languages which distinguish between dative and accusative reflexive, make a difference between partitive reflexive and oblique reflexive (Genusiene 1987:296):

me Toj se otpetla / Toj si go otpetla palto-to ‘The unbuttoned himself (acc) / He unbuttoned himself (obl) the coat’

Genusiene (1987:131,295) notes that oblique reflexives are excluded on body motions. One’s head cannot be taken off nor given back, there is no way for it to participate in a change of possession event. The feeling one gets when one tries it on is that the head is hanging loose.

1t Petras pa(*si)kele galva ‘Peter raised (himself) his head’.
fr Elle (*se) lève la main ‘She raises (herself) her hand’

To complicate things yet, Romanian does allow oblique reflexive in ru a-si ridica mina ‘to raise one’s hand’. Lithuanian and French must construe the oblique as a source or goal, Romanian as a benefactive or possessive. The least oblique reflexive entails is that the event affects the agent in some way, for this is just another way of saying there is a cyclic path in the event type. (Genusiene 1987:137).

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Passive

Passive **pass** instantiates the combinator **inv** or **BKC** which swaps arguments and drops the outer one of them. Existential quantification and abstraction both define projections of a relation, dually. Abstraction projects into one component, existential quantification projects out one component. English passive does both. Other languages may do one or the other.

I agree with Croft (2001) that typological studies starting from traditional grammar labels such as passive or subject put the cart before the horse. Each construction of each language must be studied on its own merits. The way I try to make room for this is by defining a set of simpler operations surrounding the traditional passive prototype.

Event type initial agent subject, is the natural perspective on two counts: it is iconic to time and follows the human perspective on events. A passive voice is a reassignment or reduction of arguments, mapping transitive verbs onto intransitive ones. In addition, the second argument (patient) may become subject, and/or the first argument (agent) left out may reappear as an oblique complement. In terms of combinatorst, these account to instances of projection, inversion, and projection inverse.

Let us fix some terminology. A passive event type is an event type of form y become r by x. A passive transformation is a rule which takes event type r y and converts it into event type y pass r where pass is the passive combinator (passive verb morphology, that is). Agent formation is a rule which takes event type x r and converts it into r erg x where erg is ergative case. Agentive passive is then the composition y pass r erg x.Undoing ergative gets us x y pass r and undoing passive gives back x r y.

Tagalog aptative is the prefix operator corresponding to **let**, the weak dual of **cause**. The same modality is used in Japanese to form a passive-like weak factitive construction called **adversative**.

\[ x \text{ let } y \text{ cause } q \]

Adversative and agentive passive are rationally equivalent when the subject of q is x: There is overlap, but adversative is not an instance of **pass**. The overlap is a locus of neutralisation for reanalysis.

**Passive types**

These operators allow defining a typological combinatorics of passives (Croft 2001).

Direct passive **pass** just removes (or existentially binds) the subject. Such a passive can be formed out of an intransitive. One special case of **pass** is a human impersonal passive where **cause** is instantiated to **do**, e.g. Finnish passive and French on va. The suppressed agent is only awkwardly reintroduced, if at all. The Finnish agentive periphrases toimesta or taholta ‘from the action, quarter of’ are translationese.

Hänet pidätettiin poliisin toimesta/taholta. I do p’*He (acc) was arrested due to the police’.*

Russian inanimate passive allows restituting the cause as an instrument. The object stays an object, the verb is a neuter active participle (Croft 2001).

Lodku uneslo volnami. I cause p ‘(Nature) carried away the boat with waves.’

**pass** is also found in Irish, Maasai, Turkana, Kimbundu. according to Croft (2001). The direct passive of Menomini belongs here. (Croft 2001:292).

Subject passives **be** and **become** turn the object into a subject. A state passive **be pass** turns the event to a state of the subject be done. An event passive **become pass get done** reconstitutes the event as a change in the subject. English passives are subject passives.

German **getanzt** is a passive participle x: x pass dance., i.e. x:1 cause x dance. **Es wird getanzt** has the structure I become pass dance, i.e. I become x: 1 cause x dance. This is an impersonal frame (Genusiene 1987:287). Note that only agentive intransitives fit this frame.

Agentive subject passives **agt be pass** and **agt become pass** are common combinatorial variants attested in English. Menomini indirect active and passive are subject passives. The active displays the agent, the passive suppresses it. The order of morphemes is the exact mirror image of the formalisation, which suggests that we are on the right track.

**ke-natom-ek-e-q. ‘We are called.’ become pass call x**

**ke-neqm-ek-o-q. ‘We are killed by (it).’ become agt pass kill x** (Croft 2001:292)

Croft’s data on Bambara is too scanty to venture a guess, but it is consistent with an ergative type agent marking.

The Indo-European. **middle** voice or reflexive causative **refl caus** shares forms with the passive. No surprise, for both identify the subject of the effect with the subject of the clause (Keenan and Faltz 1985). The difference is just where the first argument goes. The reflexive keeps agent focus by identifying the two arguments. Agentless passive focuses the
object and suppresses the agent. Agentive passive reintroduces the agent as an oblique adverb. For instance, the passive

o Sanskrit pacati ‘boil (tr)’ is pac-ya-te boil caus refl ‘cause oneself to boil’. Finnish passive juodaan ‘they, we drink’

is an old causative reflexive *joo-ta-hen drink caus refl.

In a passive reflexive pass refl, the reflexive first turns x kill y to x kill x which with the passive becomes 1 kill x.
Conversely reflexive passive refl pass first converts the relation x kill y to y ~kill x which reflexive turns into y ~kill y
which by the logic of causation equals y ~kill 1. This type of reflexive passive is exemplified by Spanish and Swedish.

Unergative as a diathesis operator amounts to refl caus which equals inc, while unaccusative is just pass. A further possibility is passive of reflexive causative pass refl caus, for instance The door closed by itself.
The event passive y gets killed by x is provably equivalent to y kills x x cause y become not alive. Here is a sketch of the proof.

\( \text{kill is the causative of die or cause alive,} \sim \text{alive;} \) its perfect killed is cause y alive, \sim \text{alive, which become in y gets killed} \rightarrow \sim \text{(cause y alive,} \sim \text{alive).cause y alive,}\sim \text{alive.} \) This reduces back to the event type cause y alive,\sim \text{alive.} \) The agent adverbial in present day English denotes a source x cause 1. The meet x cause 1 \&

cause y alive,\sim \text{alive} \) is tantamount to the active x cause y alive,\sim \text{alive.} \) The proof shows that an event passive only changes information structure (subject-predicate relationships).

The agentive by x has originally been an instrument or path of form \(<x<. \) This meaning is still alive in Chomsky’s
ambiguity John was scared by the new methods which can passivise either of The new methods scared John or
Somebody scared John using the new methods. There is also a state passive John was scared at the new methods where
scared just denotes the state afraid.

In present day English, an inceptive be (compare I was/got surprised) has replaced an earlier synonym of become as the
event passive auxiliary for all event types. A colloquial compositional event passive get killed exists too. The
progressive is being killed also disambiguates for event passive because states do not allow the progressive.\(^{194}\)

The logical reconstruction of a result passive is rather like this:

\[
\begin{align*}
x & \text{ beat y} \\
1 & \text{ cause 1 beat y } \& \text{ 1 cause x cause 1 (by logic of causation)} \\
1 & \text{ beat y by x (definition of by)} \\
y & \subseteq 1^\prime \text{-beat by x (conversion and left projection)} \\
y & \text{ be beaten by x (-en is combinator KC)}
\end{align*}
\]

Event and result passives fall together in the Bulgarian passive present/past, which have the same structure is/was Ved.
(Lindstedt 1985:74). The interpretation depends on aspect:

Oblacite otmivat, goneni ot vjatara. ‘The clouds pass by (ipf), chased (ipf) by the wind.’ (Lindstedt
1985:142).

The equivalence of reflexive passive and result passives is an instance of the relation algebraic equivalence
\( x=1 \rightarrow xrx=1rx. \)

\[
\begin{align*}
x & \text{ beat y} \\
1 & \text{ cause x beat y (by logic of causation)} \\
1 & \text{ cause 1 beat y } \& \text{ 1 cause x cause 1 (by logic of causation)} \\
1 & \text{ cause 1 beat y by x (definition of by)} \\
y & \text{ let 1 beat y by x (adversative inversion)}
\end{align*}
\]

\[
\begin{align*}
\text{ru} & \text{ Sosed stroit dom / dom stroitsja sosedom ‘Neighbor builds a house / house builds itself by the neighbor’} \\
\text{lt} & \text{ Kolonos laiko lubas / Lubos laikosi ant kolonum ‘Columns support the ceiling / the ceiling is supported on columns.’} \\
\text{ru} & \text{ Ozero otrazhajet nebo / nebo otrazhajetsja v ozere ‘The lake reflects the sky / The sky reflects itself in the lake’} \\
\text{lt} & \text{ Ezheras atspindi dangum / Dangus atspipindi ezhere ‘The lake reflects the sky / The sky reflects itself in the lake’} \\
\text{lv} & \text{ Udens ataino kokus / Koki atainojas udeni ‘Water reflects the trees / The trees are reflected in the water’}
\end{align*}
\]

In a personal passive the new subject is the old object, the old subject is instrument, source, location, whatever it really
is underneath the subject-predicate construction. The fact that the old subject does not become a goal suggests that the

\(^{194}\text{One might translate Goethe’s Was heute nicht geschieht ist morgen nicht getan as Was is not being done today is not done tomorrow (Jespersen 1924:274ff).} \)
cancellation or projection happens first, and then the conversion. The role revealed for the subject in the reflexive passive is its role in the causation event:

\[
x \text{ support } y = x \text{ cause } y \text{ stay on } x
\]

Many languages have both result and reflexive passives (Swedish, Russian, Lithuanian).

**Antipassive**

The agentive reflexive type of intransitives (move (by) oneself) is also known (rather obscurely) as unergative and the nonagentive reflexive, or passive type of intransitives (get lost) as unaccusative (Perlmutter 1978, Tenny 1994:59).

There is a well known tendency for ergative to be restricted to perfect(ive) aspect (Trask 1979, Chung/Timberlake 1985, Johanson 1998). In this type of split ergative pattern, patient-oriented (ergative or passive) diathesis is associated with perfect(ive) aspect and past tense, while agent-oriented (active or antipassive) diathesis goes with imperfective aspect and future tense (Trask 1979, Delancey 1982:167, Klaiman 1991:47). A classic example is Georgian (Boeder 1979), where imperfective forms are active and perfective forms ergative:

Past tense forms are often etymologically derived from passive perfect participles and imperfective forms from active present ones. Georgian has different case markings for imperfective, perfective, and perfect. The imperfective is active, the perfective is ergative, and the perfect is a state passive. The perfect resembles English ‘the men have a letter all written up’.

Another instance is Indonesian, where the passive is perfective (Chung/Timberlake 1985) and the active imperfective. Here are examples from Galgadungu and Gujarati (Delancey 1982):

Example from Sama (Lapolla/Van Valin 1997:301):

- kaceb-i čer-en čeril-s ‘The men (nom) are writing (ipf) a letter (dat).’
- kaceb-ma dačer-es čeril-i. ‘The man (erg) wrote (pf) a letter (nom).
- kaceb-s u-čer-iat čeril-i. ‘The men (dat) have (apparently) written (perf) a letter (nom).’

Some ergative languages have marked active voice called agentive or antipassive (Lapolla/Van Valin 1997:§6.4). It denotes a process toward bringing about an event. It adds an agent to an unagentive event type and turns it imperfective.

\[
\text{act p' cause q : q}
\]

The definition shows act to be a denotational variant of caus. The difference (when there is one) is that the antipassive event type denotes the process and at best implicates a result. The morphology of an antipassive is intransitive: either reflexive or medial (causative-reflexive) as in Dyrbal, Lapolla/Van Valin 1997:302, Klaiman 1991:46) or progressive or iterative (be + verbal noun or participle in Ingush, Lapolla/Van Valin 1997:299). The case of the object, if any (it may also be incorporated or otherwise generic), is dative (goal) or instrumental (path) case (Lapolla/Van Valin 1997:295).

Reflexives are intransitive because they identify arguments. Progressives are intransitive because they perform subject-predicate abstraction on the process subject of cause. The antipassive operator is instantiated by both frames. Aspectually the antipassive is imperfective (Comrie 1979:254). That comes from the cause half of the canonical structure of the causal chain: an agent does something (process) (to and by itself) until something happens to something (else) from it (change).

Example from Sama (Lapolla/Van Valin 1997:301):

- B’lli d’nda daing ma onde’. **buy woman fish to child** The woman (has) bought (the) fish for the child.’
- N-b’lli d’nda daing ma onde’. **act buy woman fish to child** The woman is buying fish for the child.

The symmetry of agentive passive and antipassive extends to case marking. When an antipassive subject appears as oblique, it gets source case; when an object does, it gets goal case. An instrumental case fits both.

In reflexive antipassive, the object becomes an oblique, and the verb becomes reflexive. This is an open agentive event type, characteristically iterative (Genusien 1987:95).

\[
\begin{align*}
\text{It} & \quad \text{Jis meto akmenis / Jis metosi akmenimis 'He throws stones / He is flinging round with stones'} \\
\text{ru} & \quad \text{On brosajet kamni / On brosajetsja kammjami 'He throws stones / he is flinging round with stones'} \\
\text{fr} & \quad \text{Elle moquait tout le monde / Elle se moquait de tout le monde 'She mocked everybody / She mocked herself of everybody'} \\
\text{ru} & \quad \text{On rojet jamu / On rojetsja v jame 'He digs a hole / He digs himself in the hole.'}
\end{align*}
\]
What seems to be happening here is that

x cause x dig cause hole

goes to the imperfective event type or initial prefix

x cause x dig’ cause x

which comes by a final cause inversion

x plan y cause x cause x dig

The planned hole causes one to dig. This is the duality of effective and final causes. Plans are dual to their realisations. The event type is agentive because of the reflexive x cause x dig. It is an object reflexive because the object of the event type is now x, while y is just a plan being worked at. The planned object is goal case because that is where the effort is going to.

Sometimes the case of x is not a goal case but, say, location or instrument. One reason is that the hole to be is round there before it is not finished, as an unfinished hole, a virtual, planned hole. (One actually sits in the hole when one digs it.) A related idea here is the German progressive sich mit etwas beschäftigen, make oneself busy with something, bei etwas arbeiten.

Cyclicity and iteration

Antipassives evidence the duality between cyclicity and iteration mentioned in the section on group theory. Finnish has a tendency to translate Lithuanian antipassive type reflexives with an iterative derivative.

It Ezheras atspindi dangu / Dangus atsipind sauztis / The lake reflects the sky. / The sky reflects itself in the lake

fi Järvie heijastaa tava / Taivas heijastelee järve / The lake reflects the sky / The sky is reflected / keeps reflecting from the lake.


Many of Genusiene’s (1987:§2.1.6.1) nominal reflexives translate to denominal reflexives in Finnish too, e.g. It sieva ‘wife’ sievoties ‘make oneself with wife, marry’, fi akka ‘wife’ akotitaa ‘make oneself with wife, marry’. But others translate to iteratives, for instance It bralis ‘brother’ braloties ‘make oneself like with brother, fraternize’ fi veli ‘brother’ veljellä ‘behave as brothers, fraternize’. The English progressive He is being brotherly belongs here too.

Iteration is a common implicature of reflexive across languages of the world (Genusiene 1987:338).

Another phenomenon. In English, there is a difference between wash and soil or clean. Wash oneself allows implicit reflexive wash, soil oneself or clean oneself do not. How to characterise verbs which do (not) take part in the agentive reflexive alternation in English? On the positive side, those who do are things people usually do themselves, like wash, shave, dress, comb. (Genusiene 1987:191, Jespersen 1927:325-329, Lyons 19968: 363-363). This observation makes logical sense, for it was noted in the section on relation algebra that \( arb = ar \) just when \( b \) is the codomain of \( r \), i.e. \( arb = ar1 \). The codomain is redundant when it can be inferred.

But there is another difference. The positive lot are antipassive type activities, open accomplishments or manner causatives. The negative cases are one-shot affairs. Witness throw oneself, place oneself. Throw and place do not match the entire event, but only a beginning/cause (throw) or end/result (place). The same is true of the result causatives soil and clean. Also balance (oneself), hide (oneself), rock (oneself), stretch (oneself), squeeze (oneself) are open. Compare compose oneself to decompose (itself). I composed myself for a while is likely to mean my composure kept for a while, while The substance decomposed for a while can well mean that the process took time. The substance decomposed itself is in fact likely to mean all of it did. This looks like an instance of measuring out (quod vide).

Genusiene (1987) studies oppositions like repeat (itself), double (itself), offer (itself), show (itself), versus suggest itself, manifest itself, lend itself, duplicate itself. There are a number of interrelated tendencies. The alternating relations hold between similar things. The nonalternating ones hold between unequals, many of them animate-inanimate. The alternating ones are open: processes or comparative changes, the nonalternating ones closed simple changes or cycles.

All points to an equation between cyclic event types, cyclic causation, and iteration. An event type repeats itself just when it causes itself if anything does.
Causative-passive conversion

The causative-passive (inchoative, anticausative) alternation is a common one (Genusie 1987, Haspelmath 1993). The first point to note is that the alternation does not go just one way. As this involves lexical derivation, accidental gaps may occur. The presence of a form is positive evidence, but the absence of one may be an accident. In some cases there is no way to tell, either because the form is the same (known as grammatical conversion), or both forms are derived or suppletive. One heuristics is that the causative (transitive) form can be basic when the change does not happen without an identifiable cause and the inchoative (intransitive) one when the opposite is the case. But many cases go either way, compare for instance

ru rasplavit ‘melt something’ passive/reflexive rasplvit ‘sja ‘melt’
fi sulaa ‘melt’ causative sula-ttaa ‘melt something’

Adjectives are productive sources of causative/inchoative pairs: fill, widen. Haspelmath finds that English verbs like break, burn, melt, roll, open participate in conversion but verbs like work, dance, cut, build, criticize, sleep do not. The suggested difference is that the former are inchoative (instantiate become) while the latter are not. Haspelmath’s constraint implies that the source verb must allow a nonagentive, inceptive sense. Some of the recalcitrant verbs do seem to have an agentive or medial base (involve do). For a minimal pair, compare The child walks/works when you walk/work her. The causative use of work is marginal all the more work is medial (agentive-reflexive). Some are instrumental (involve use), like cut.

Ritter/Rosen (2000:200, cf. Ritter/Rosen 1998, Brousseau/Ritter 1991, Levin/Rappaport 1995) mention as a well-known fact that a causative interpretation is only available for and English intransitive verb if it is delimited (achievement or accomplishment, i.e. closed), mentioning as a minimal pair break and dance. The result causative break converts fine, but a manner causative dance wants a result adverb:

Sue danced Bill across the room.

Pace Ritter/Rosen, a manner causative can be open (denote an activity): Sue danced Bill around the room / on her knee. Similar comments apply to burn, roll, ring, flash et cetera.

Oblique causative and passive

Oblique inversion gets grammaticalised as diathesis in some languages. Applicative, for instance in Swahili or Fula, produces from give x to y. the frame give y x.

app x cause y have z : x cause z be with y

The following interchangeability thus holds: app cause p equals cause inv p. Morphologically, an applicative is often just a goal case glued to the verb. Semantically, it denotes its inverse.

Applying passive or causative to this produces an oblique passive ‘be given (to)’, grammaticalised in Tagalog. Tagalog even has forms for an active or passive causative of oblique causative. ‘make someone given (to)’, ‘be made given to’. English prepositional oblique passive prefers that the oblique subject is also subject to change. That is the difference between

The bed was slept in /outside.

In Lillooet, there is a small number of free roots of unaccusative diathesis like lhval ‘to be left’. Four suffixes increase arity: agentive, causative, oblique causative, and passive causative. Three suffixes reduce arity: antipassive, reflexive, and middle (a direct or oblique reflexive). Languages of this type are pure combinatory logic.

Examples of Fula applicative and passive (Klaiman 1991). Both objects can be passivised here.

Be kirs-an-ii min ngaari. they slaughter app past us bull ‘They slaughtered for us a bull.’
ngaari hirs-an-aama min bull slaughter app pass us ‘A bull was slaughtered for us’
min kirs-an-aama ngaari us slaughter app pass bull ‘We had a bull slaughtered for us’

In the applicative causative, in contrast, appears to allow one passive. Rather they don’t amount to the same. The schema for applicative causative is cause app

Puccu yarnii ndiyam horse drink water ‘The horse drank water’
o yarnii puccu ndiyam he drink cause horse water ‘He let the horse drink water.’
puccu yarnaama ndiyam horse drink cause pass water ‘The horse was allowed to drink water.’
ndiyam yarnaama puccu water drink cause pass water ‘Water was allowed to drink the horse.’
Inverse voice

Dialogue players, first and second person in particular, often get special treatment in voice systems. Finnish passive object case marking is split between a special purpose accusative in for human pronouns (me, you, who) and nominative for the rest. Irish passive makes a similar split. Some ergative languages use unmarked active voice for grammatical persons and passive for the rest.

In English too, passive is sensitive to agency and perspective. In the next pair, the train is a theme (subject of go) in the first pair, while the stranger is an agent (subject of do) in the latter pair.

A train approached me / ?I was approached by a train.

A stranger approached me / I was approached by a stranger

Cree inverse voice (Croft 2001) voice is marked on the verb. The order of the nominal arguments can be free as far as role marking is concerned. There need not be any marking on the nominal arguments (Klaiman 1991:65).

An inverse voice system is said to mark events which reverse the flow of control defined by an animacy hierarchy. Mysterious. What does it mean to be “more animate” anyway? Looking at examples, I think it simply means being responsible for an event. When examples are translated with this in mind, the inverse voice system starts making honest Western sense. Take for instance Navajo:

at’eed tó yodláá’ girl water dir drink ‘The girl made herself drink the water.’

*tó at’éd bódláá’ water girl inv drink ‘The water let itself be drunk by the girl.’

*awéé’chi’i díné yíztał baby man dir kick ‘The baby got itself to kick the man.’

díné ‘awéé’chi’i biztał man baby inv kick ‘The man let himself be kicked by the baby.’

Klaiman (1991) cites examples from San Carlos Apache (Shayne 1982) in which animacy is not the decisive factor, but causal responsibility. Witherspoon (1980:9-10, quoted in full in Klaiman 1991:178) is worth quoting in patches here:

[lii hastiin yíztal horse man dir kick ‘The horse made himself kick the man’]

is not […] poor grammar […] it is not within the intellectual capabilities of the horse to conjure up a plan […] by which he decides […] he will give the man a swift kick. […] If a man gets kicked by a horse it is his own damn fault […] Horses kick men because men allow themselves to be kicked […] there is only one way to describe such an event:

hastiin lii’ biztał [man horse inv kick ‘The man let himself be kicked by the man]

The sentence should be translated the man let (or caused) the horse to kick him.

Leaving out bits about Navajo folklore, what we are left with is the semantics of the Navajo direct and inverse voice in bare bones.

Formally, the direct voice, if marked, is an agentive x cause x cause x p, while the inverse voice is an adversative x let y cause x p. Note that these operators, like the middle voice, do not change arity (Klaiman 1991:183). One conclusion is that the animacy hierarchy is not needed as an independent explanatory principle. It is but an epiphenomenon, a reflection of event structure.

The direct/inverse voice distinction is in principle orthogonal to the active/agentive passive voice distinction in so far as the former concerns the attribution of cause and effect and the latter the order of arguments. In practice, they are interdependent due to iconicity and shared morphological implementation. Remember that adversative x let p entails passive ¬x cause p in zero-sum games.

Natural serialisation

A binary diathesis operator can morphologically appear as a prefix, infix or suffix (postfix) operator. In addition, its arguments can come in direct or inverse order. Languages (or perhaps better, given constructions in given stages of a language) show some consistency in their choices here, being more or less systematically prefixing or postfixing. A principle called natural serialisation in Vennemann (19??) says that languages are even more consistent in the layering of operators, whether pre- or postfixal, so that direct order is more common than inverse order.
For instance, Finnish is a postfixal language which has a good array of suffixes corresponding to the English abstract verbs \textit{cause} and \textit{become}:

\begin{center}
mies nime-n pah-en-taa & man (nom) name (acc) bad-\textit{become-cause}
\end{center}

The word order of the preverbal nominal arguments is the order usually considered to be the old word order in Finnish, an earlier verb final language. Note that it is the mirror image of the order of the derivative suffixes, which are stacked in their natural operator-operand order. If we look upon the suffixes as two-place postfix operators, we can see that the only change to speak about here is a change in associativity due to the composition (currying) of the two operators into one:

\begin{center}
man (name bad become) cause man name (bad become cause)
\end{center}

There are exceptions to natural serialisation, indicating that conflicting aims and organisational principles are at work. One of the foremost counteracting forces is aboutness, topicality, or reference tracking, i.e. the need to make clear what one is speaking about in a bit of dialogue.

\section*{Aspect and diathesis}

Kurylovicz (1964:93), anticipating Moens (1987), describes a prototypical event as composed of a preparatory process, a culminating change, and a consequent state: in my notation, \textit{p.c.r}

\begin{center}
M \quad O \quad N
\end{center}

\begin{center}
Imperfective \quad \text{perfective} \quad \text{resultative}
\end{center}

\textbf{Table 57}

Here, MO stands for the preparatory process, O for the point of culmination, and ON the consequent state (Cohen 1989:106). As pointed out by Smith (1991:35), Moens (1987) and Croft (1987,1990), these central aspect types reflect different phases in the causal chain as follows:195

\begin{center}
john plan \quad \textit{cause} \quad john hammer \quad \textit{cause} \quad \textit{become} \quad \text{metal be flat}
\end{center}

\begin{center}
\text{process} \quad \text{change} \quad \text{state}
\end{center}

\begin{center}
\text{activity} \quad \text{accomplishment}
\end{center}

\textbf{Table 58}

The \textit{cause become} schema is thus the backbone of a prototypical event: an activity causes a change which results in a state. The schema divides a prototype event into two (or three) subevents, a cause, which is an agentive, modal, active, atelic, open, nonpast process, and an effect which is a passive, telic, indicative closed nonfuture change of state. Call the two subevent prototypes \textit{forward} and \textit{backward}, in want of better names neutral between TMAD dimensions.

Languages may vary in which aspect of each prototype they primarily code. The prototype provides the loci of neutralisation and developmental paths along which changes will take place, the epigenetic landscape of TMAD systems. It is good advice to keep this prototype in mind and look for its exponents in different languages.

This is all old hat to traditional grammar and current typology. The main novelty, if any, of my formalisation is the attempt to turn the associations into definitional relationships. Through the chain of definitions provided in this work, the observed clusters of descriptive terms can become hard and fast entailments.

The prototype is a simplification. Many changes are vague between absolute and comparative change: shorten a skirt can mean make short or make shorter. The former is closed, the latter open. McCawley (1976) notes that different causative verbs differ in aspect in ways which reflect the aspect of the cause and the effect: ballistic causation like \textit{shoot} is an achievement because releasing a shot and dying are; continuous causation like \textit{boil eggs} is an activity because

\footnote{A minor correction: the planning is also a process accompanying the hammering.}
boiling is a process, and culmination *dress the child* is an accomplishment because getting dressed is one. He also has a nice example showing that perceived aspect depends on factual cause and effect relationships. In *Haro* squeezed the orange/tennis ball in 20 seconds

*squeeze an orange* is an accomplishment, because oranges produce juice until dry, while *squeeze a tennis ball* is most likely just a (cycle of) a dynamic state, because tennis balls bounce back to shape.

Argument structure alternations change aspect in predictable ways. There are pairs of inversely related aspect and diathesis changes which produce new lexical frames or lexical entries across languages. Starting from the aspect type on the left, it is possible to get to the one in the middle and back using the inverse operators.

<table>
<thead>
<tr>
<th>change</th>
<th>causative</th>
<th>accomplishment</th>
<th>p cause c</th>
<th>passive</th>
<th>change</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity</td>
<td>p</td>
<td>agentive</td>
<td>accomplishment</td>
<td>p do c</td>
<td>reflexive</td>
<td>activity</td>
</tr>
<tr>
<td>activity</td>
<td>p</td>
<td>generic</td>
<td>state</td>
<td>s</td>
<td>progressive</td>
<td>activity</td>
</tr>
<tr>
<td>accomplishment</td>
<td>p</td>
<td>imperfective</td>
<td>activity</td>
<td>p</td>
<td>perfective</td>
<td>accomplishment</td>
</tr>
</tbody>
</table>

Table 59

There is a well known connection between aspect and diathesis, in particular (in)transitivity and (im)perfectivity (Chung/Timberlake 1985). A prototypical causative event is ergative, past, perfective and transitive, focuses the effect and topicalises the patient, while a prototypical intransitive event is active, future, imperfective and intransitive, focuses on the cause and topicalises the agent.

All these observations are corollaries of the different positions of agent and object in the causal chain and the asymmetry of time (Delancey and Wallace in Hopper 1982). The subject of the cause is the agent and the subject of the effect is the object. A transitive event is closed when its effect is closed and open as long as the cause is. At the time of the cause, the transitive event is yet to be completed (future); at the time of the effect, it is already there (past). Agentive voice focuses (abstracts on) the cause, passive voice focuses (abstracts) on the effect. Accusative case marking topicalises (makes into surface subject) the subject of the cause, ergative case marking topicalises the subject of the effect.

**Agentive-accusative:** x be x cause q

**Passive-ergative:** y be p cause y q

Nominative-accusative systems develop from predicative abstraction of agent from cause while the object is marked as a goal. Absolutive-ergative systems develop from predicative or possessive abstraction of object from effect while the agent is marked as source.

Participial passives are formed from perfect participles, which in turn are resultative adjectives (Trask 1979, Chung/Timberlake 1985). The default participles are an active present participle and a passive perfect participle. This follows from the causative analysis of transitivity. A participle too is a one-place reduct of a verb. If the verb is one-place, there is only one participle to form, and that is the active present participle.

If it is transitive, there are two, one from each argument, represented by \[x: \text{x cause q}\] (‘the x that \text{p to cause q}’) and \[x: \text{p cause x q}\] (‘the y that \text{q as a result of p}’). Respectively. By the *propter hoc* principle, the former participle is present active and the latter one perfect passive. It would be typologically more revealing to talk about cause/effect participles here. This even shows in English *he is drunk* from intransitive *he drinks* vs. *it is drunk* from transitive *he drinks it* (Johanson 1998:§8.5.1.2).

This explains Dahl’s (1985:135) observation of a high correlation between passive voice and resultative constructions. In many languages, resultative constructions are only found in the passive voice. Cf. section on perfect typology.

Another well known phenomenon is that the aspect of a passive participle depends on the aspect of the input. Jespersen (1924:273) reports Diez’ division of verbs into two aspect classes:

In the first the action is either confined to one single moment, e.g. *catch, surprise, awake, leave, end, kill,* or imply a final aim (endzweck), e.g. *make, bring about, adorn, construct, beat*; here the passive participle denotes the action as accomplished and finished, and the combination with *sum* in Romanic as in Latin is a perfect. Diez calls these verbs perfective. The second class (imperfective) comprises verbs denoting an activity which is not begun in order to be finished, e.g. *love, hate, praise, blame, admire, see, hear,* etc. Here the participle combined with *sum* denotes present time.
For example, a killed person is a dead person (one who has been killed) but a hated person is one who is being hated. This apparent difference follows from the Aristotelian definition of result: the result of an open event is that event itself, hence to become hated is to be hated, and to be hated is to have been hated. For imperfective event types there is thus little difference between event and result passive.

Jespersen (1924, 1949:§8.1.2) notes that perfective passive participle tend to become lexicalised into adjectives losing their temporal signification, i.e. the form comes to denote the event type of the result event, e.g. filled with becomes to mean just full of. Such a form is no longer a passive nor a perfect. Call them state passives (cf. state perfects). In other cases, a past event may be inferred but it is not open for reference, e.g. it cannot have event modifiers like slowly, deliberately. They could be termed result state passives. Often there is an ambiguity between an event and a result state passive, for instance the following is consistent: The door was shut at five but it was not shut then (Jespersen 1924: 274).

For perfective event types, there is a difference. The result or state passive y is killed is a perfect with the form y be x: cause x alive~alive denoting a state of being not alive caused by something. A further lexicalisation from died to dead formally means that the left quotient operator is applied on the event type rather than the event token (‘the state that results from dying” instead of “a state that resulted from dying”), leaving just the result state ~alive.

Aspects as combinators

One can recast aspectual event types in the form of combinators. A state s is trivially represented by the identity combinator I_s. A change is an instance of combinator S by S~I_s = ~ss. A cycle C = ~Is_s = s^2~s corresponds to a change followed by the reciprocal change. Permanence ss is obtained by SIs, which equals the reflexive combinator W_s. An activity is an iteration of a cycle or permanence.

This provides another connection between activity, reciprocality and reflexivity. Recall that an activity was defined by Aristotle to be an event which is its own result: a cause a, which makes an activity literally a case of reflexive causation.

Interestingly, Finnish iterative suffix -el- on transitives often has an agentive reflexive, medial or reciprocal effect: tappaa/opetella ‘kill/fight’, rakastaa/rakastella ‘love/make love’, harjoittaa/harjoitella ‘practice/practice oneself’, opettaa/opetella ‘teach/teach oneself’, kuvittaa/kuvitella ‘picture/picture oneself’, huvittaa/huvitella ‘amuse/amuse oneself’ (Hakulinen 1968:§60,66). Open aspect singles out the reflexive event type x cause x in the agentive do schema and vice versa, which makes reflexive and iterative a locus of neutralisation. See also section on reflexives.

Theories of diathesis

Theories of diathesis reflect the typological variety of the languages in the world (Lapolla/Van Valin 1997:Ch.6). Natural languages range from analytic through agglutinative to synthetic. These types differ among other things in how argument places are identified: configurationally, by separate particles, by labels on the dependents (dependent marking) , or by labels on the head (head marking), or a combination of the above (Nichols 1986, Lapolla/Van Valin 1997).

Diathesis theories, like function-argument representations at large, also come in two main varieties, positional (arity-based) and labeled (attribute-value) ones. A positional system distinguishes argument places by ordering and/or nesting them, a labeled system by labeling them. Argument structure representations are positional, role and case representations are labeled. Labeling systems can be further divided into relational ones, where the label stands alone, case representations, where the label is on the argument, and role representations, where the label is on the predicate.

Languages -- and theories - differ further in how they represent diathesis shifts. The spectrum is largely analogous to the situation with aspect.

Received theories assume a fixed number of levels of representation connected by linking rules. The number and depth of levels varies. Traditional grammar distinguishes between logical, psychological and grammatical subjects or objects. Active voice is described as a construction where logical and grammatical subjects coincide, passive as one where the logical object is the grammatical subject.

Transformational grammar in its many varieties sticks to positional representation of arguments. Roles are defined configurationally. In the question of the number of levels, there have been revolutions and reformist movements between monism (generative semantics), dualism (standard theory), and varieties of polytheism. Van Valin’s Role and Reference Grammar (Van Valin 2002) works with three levels.

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196 There is an analogous cline between taxonomic (or two-level) and generative (or compositional) phonology with or without levels.
Many theories of diathesis posit a cross-linguistic role accessibility hierarchy (Keenan, Comrie, Dik 1978:76, 1989:226, Givón 1979, 1984, 1990, Lapolla/Foley 1997:236, Bresnan/Moshi 1990) to predict the choice of grammatical subject and object, among candidate roles. Subjectworthiness declines going down the nesting of the roles in the causal chain. The details of the suggested hierarchies differ. The common logic is that linking rules choose the best grammatical role filler among available candidates using the hierarchy as the preference relation. An alternative is to consider the accessibility hierarchy an epiphenomenal projection of the causal chain. Subjectworthiness reflects the distance of a role from the root. Arguably, the difference between this account and the linking rule account is only one of perspective.

Diathesis typology is usually conducted top down, from function to form. Taxonomic typology starts from some functional prototype or cluster like passive, perfect, or future and studies how it is manifested across languages. The shared function is used to explain variation and unity of structure. Croft (2001) goes a step further from taxonomy to correlations of functional scales, called semantic maps or spaces. For instance, a semantic map called the Subject Construction Hierarchy predicts that active voice goes with foregrounded event type and high topicality, while passive voice goes with backgrounded event type and low topicality.

In analogy with my aspect theory, my diathesis theory works bottom up, from form to function. The diathesis calculus is compositional, making no sortal distinctions between levels. The work of linking rules is done by diathesis operators, variously coded in the language, possibly including unmarked diathesis shifts. The only levels to talk about in this approach are constituted by the formal devices coding diathesis: lexicon, derivational and inflectional morphology, and grammar.

To make the bottom up approach work, paying close attention to morphology and etymology pays off. Many patterns curious at a distance make sense first when the history is known. Languages change, and are midway through a change much of the time. Double markings are often made up of sediments, the newer layer more productive and transparent. Splits often happen between persons, first-second or third person heading an innovation. The natural me first policy may be counteracted by a polite you first inversion, cooperative because it is me first for you.

An advantage of the bottom up approach is its morphological concreteness. It captures the observation by Lapolla/Van Valin (1997) and Croft (2001) that diathesis type is construction specific rather than language specific. It makes room for fine grained diathesis variation, like the Lango passive where the object becomes subject without the agent getting demoted (Lapolla/Van Valin 1997:295ff), or the Ute or Finnish passive where the opposite happens. The top down functional and bottom up morphological approaches complement one another. Genusiene (1987:235) finds that languages differ much less in the range of semantic verb types than in the ways of expressing them. In principle semantic types may be marked in any language specific way conceivable. I think the converse holds as well. The expressive means in languages are also quite limited so that precisely the same constructions and metaphors repeat themselves across languages to express similar meanings. Both perspectives thus impose dual limitations on what can be said and how it is said.

The theory of diathesis developed here is a conservative extension of the calculus of event types developed earlier. This brings with it at least two advantages. One consequence is that the theory of aspect is formally a projection (subset) of the theory of diathesis, allowing diathesis to explain aspect.

Another consequence is that theory of diathesis forms an algebraic calculus in the same way as the aspect theory does. It follows that the classification of event types by argument structure induced by this theory is a (Boolean) lattice instead of a fixed taxonomy (Levin 1993).

For instance, it is possible to represent a given verb like say at the same time as a subtype of agentive verbs, causative verbs, motion verbs, verbs of change, verbs of communication, and propositional object verbs. It also follows that one need not ask what type a given entry is basically, say whether eat is basically an activity or accomplishment (Lapolla/Van Valin 1997). eat means eat something, which is an activity when something is open, an accomplishment when it is closed. The event type of eat is what is basic to it.

A perception verb like see, to take another example, might be represented as a two-way causation. The activity of looking allows the object to impinge on the experiencer. The object causes the perception, but the subject enables it by looking in the right direction. Because of the two-way causation, both experiencer and cause have a multitude of roles for languages to focus on.

Yet one more advantage is that diathesis operators can be defined on event types of given generality. For instance, if there is a systematic alternation throughout the verbal system of a language, as in Lakhota where states double as changes (i.e. are acquisitions), this can be associated on the type instead of its separate instances.

**Space-time metaphor**

There is a long literature on space-time metaphor, i.e. structure preserving mappings across domains in natural language, in particular across the domains of space and time. The phenomenon is actually more general than the title suggests: the
space-time coordinates of natural language also get transposed to other coordinate systems with similar structural properties.

Many writers have pointed out a genetic priority of spatial terms over temporal ones (Piaget 1970, Clark 1973, Anderson 1973, Bennett 1975, Traugott 1978, Frawley 1992), but there are metaphors in the reverse direction as well. Through space-time metaphors, various event types can be transposed to spatial properties of inanimate subjects. These are not habits or dispositions but simple states (they can be verified from a still image.) Such spatial uses may have dedicated argument frames.

The ladder reaches the ceiling.
The house is surrounded by a wall.
The river meanders through the landscape.
The road leads to the cottage. (cf. The man is leading us to the cottage.)
The sign points to the tower. (cf. The man pointed at the tower.)

The examples above are spatial states (Langacker 1982:274ff, Parsons 1990:203ff). Spatial states can be understood as mapping events to space. They describe spatial relations in terms of tracing events (Langacker 1987), movements of an object tracing the contours of a spatial configuration through specious time. Curve tracing using a directed one dimensional parameter set is a standard topic in calculus (Ayres 1964). Because clock time is not involved, these sentences are simple states. The state may have resulted from an event of the same type or not.

… Ja … uvidel daleko pod soboi ogromnuju ravinu. Shirokaja reka ogibala ee uhodjashchim ot menja polukrugom: stal'nyje vody, izredko i smutno mercaja, oboznachali ee techenie. ‗I saw (pf) far below an enormous plain. A wide river encircled (ipf) it in a receding semicircle, iron-grey waters, giving out an occasional dim flash, marked out (ipf) its course.

A message is a representation, a likeness of a situation or an event, i.e. a spatiotemporal metaphor. Repeatable messages: recordings, images and texts support timeless present tenses about what is the case, happens, or is happening in the representation. References to places in a picture or book are interchangeable with references to time here. Stage instructions are written blow-by-blow accounts of the events in the play: enters the villain ‗the villain enters now/here/at this point‘.

In the lower left corner the artist‘s children are playing with a ball.
In the next chapter/the following morning the hero meets his future wife.

Once created, a representation has a life of its own. Author-work metonymy (a special case of agent-instrument metonymy) makes it possible to go freely from the author represents something with the work to the work represents something.

The sign forbids fishing here. (The owner forbade fishing here.)
My theory solves this problem. (I solved the problem.)
Herodotus (his book) tells us about the Persian wars.
Herodotus is referring to the Persians in this passage /This passage in Herodotus refers to the Persians.

Metonymically, the author too has a literary presence now through his works. It is only a half life, because it only supports facts which can be transposed into assertions about his preserved works or deeds (Lakoff 1970:844, Inoue 1979:580).

Shakespeare is a renowned playwright. (Shakespeare‘s plays are famous.)

Shakespeare has written impressive dramas. (Impressive dramas have been written by Shakespeare.)

Shakespeare is/was a notorious drunkard. (Not a fact about Shakespeare‘s works.)

Shakespeare has/had quarreled with evey other playwright in London. (Ditto.)

Cicero writes/wrote poems too. (Cicero‘s poems have been lost.)

Hawthorne was so exceptional a writer that he has very generally been esteemed a great one. In America such an estimate has been almost universal. He won his way slowly.

He [Clive] was in consequence accused by his enemies, and has been accused by historians, of disobeying his instructions. (Jespersen 1949:§5.4.5)

Temporal adverbials too have nontemporal uses (Cresswell 1974,1979,1985, Lewis 1975). There is a space-time metaphor in The road crosses the railway twice in ten miles.

Parsons (1990:224) argues that frequency adverbials may quantify over events rather than times: Caesar was stabbed (a lightning struck down) twice at exactly the same time seems a possible description. The events here can be events in a statistical sense, or cases: Children die in car crashes more often than adults. A country with a prime minister often/always/never has a parliament.
Scale adverbials allow space-time metaphors as well as other transpositions: Bazel is already in Switzerland. Two wives is still manageable, but four wives is already too much. Cetera iam fabulosa ‘the rest is already fiction’ (Tacitus).

An inverse case of space-time metaphor are spatial adverbials of time like all the way, all along. That these are temporal adverbs can be seen from their ability to modify stationary events:

The bells tolled all the way to the church.

This can mean bells tolled all the while somebody was on the way to the church. Finnish can make this explicit with koko matkan (ajan) ‘the time of) the whole distance’. As a consequence of the metaphor, the following English sentence is ambiguous:

The kids chased the cat all the way to the cottage.

Did the kids make the cat run to the cottage, or did they just chase it round on the way there? The Finnish translations are different:

fi Lapsset jahtasivat kissaa mökille saakka.’The kids chased the cat (ptv) until the cottage’
fi Lapsset jahtasivat kissan mökille saakka. 'The kids chased the cat (acc) until the cottage.'

The former translation is vague about whether the cat gets to the cottage, while the latter entails it.

Compare also The hedgehog was in a ball. Finnish disambiguates this with (in)essive case: Siili oli pallossal pallona. Essive case denotes nonspatial or temporal inclusion (role), inessive spatial inclusion (place).

### Adverbial classification

Parsons (1990) cites a semantic classification of adverbials which relates to diathesis. Changing names to fit my thinking, the classes are:

1. **speech act modifiers:** fortunately, perhaps, however, frankly
2. **proposition modifiers:** possibly, in the story
3. **action modifiers:** willingly, rudely
4. **event modifiers:** quietly, with a knife
5. **time modifiers:** soon, twice
6. **adverbial quantifiers:** only, also

Action modifiers constrain the mental cause of an action frame (do). Event modifiers can be further divided to **role adverbials** which indicate slots in the main argument frame (for instance instrument with a knife) and **manner adverbials** (proper) which describe the event otherwise (e.g. quietly). In closer analysis, proper manner adverbials may constrain further events accompanying the main event; its causes, effects, or other conditions. For instance, quietly may mean ‘without causing noise’.

### Object types

The category distinction between verbs and nouns, or events and objects, teems with morphisms. No wonder given that the categories are at best a duality apart. One family which is relevant for TMAD is is the count-noncount distinction.

Analogies between nouns and verbs which indicate that the count-noncount distinction cross-cuts the nominal and verbal domains are known since Aristotle (Ar. Phys. 235a15-19, Taylor 1977, Mourelatos 1978). The analogy extends further to the distinction between comparative vs. absolute qualities. The analogy affects aspect in the way the count-noncount distinction on nominal arguments of verbs is reflected in the aspect behavior of verbs, but also more directly, in the way events themselves can be divided into count and noncount ones (Davidson 1967, Mourelatos 1981). It shows in the distribution of duration/frequency adverbials as well as in nominalisation: Vesuvius erupted three times = there were three eruptions of Vesuvius; They played a little Mozart = Mozart was played for a while.

A Parmenidean duality of many and one, even and odd, logic and topoi is lurking behind the distinction. Booleans are closed under joins and complements and define the two-place relation of more and less which characterises noncount reference. Topology is closed under joins and finite meets and defines the three-place relation of separation which characterises count reference.

### Genericity

The simplest statements about everyday objects are generic. Take for instance The earth is blue. Looking from space, the earth is blue. Looking a little closer, it may not be all blue, just more or less blue. Looking even closer, it is clearly partly blue; more specifically, that it is the the seas that are blue while the continents exhibit a lot of other colours. Looking at the seas more closely repeats the process.
Plural generic sentences of form \( A \equiv B \) are vague assertions about kinds viewed as individuals (G. Carlson 1977, Dowty 1979:83ff). Genericity is thus a case of granularity. (Cf. the concepts of abstraction and scale in cognitive grammar, Langacker 1987:118,132ff.) A generic assertion implies coarse grain, as it describes the outlines that emerge when detail below some threshold is left out of the picture.

Generic plural sentences have a vague and negotiable relation to extensional generalisations about individuals, a relation which changes with the degree of precision required. The point is that generic sentences are vague and negotiable by design. A generic sentence is a rough outline of a theory, waiting to be made more precise. One cannot say whether a generic sentence is true or false simpliciter, that depends on how it is narrowed down. There is an upper bound (all \( A \equiv B \)), a lower bound (some \( A \equiv B \)) and a middle (most \( A \equiv B \)) where \( A \equiv B \) begins to be a better generalisation than \( A \not\equiv B \). Like the description of the earth, a generic sentence can refined extensionally by making it statistically more accurate, or refined intentionally by making the conditions of the dependence more accurate. The adjectives describing generic assertions are not true/false, but accurate (to a point)/misleading.

Understanding generics calls for Boolean algebra or generalised quantifiers instead of first order quantifiers. Instances of a generic sentence \( A \equiv B \) compare \( A, B, A \cap B \) and \( A \setminus B \). All \( A \equiv B \) can be expressed as \( A \subseteq B \), or \( A \cap B = A \), or \( A \cup B = B \) or \( A \cap B = \emptyset \), or \( A \rightarrow B = \neg \emptyset \). Some \( A \equiv B \) is the case when \( A \cap B \neq \emptyset \), or \( A \setminus B = A \). Many \( A \equiv B \) and More \( A \equiv B \) compare \( A \setminus B \) to some other set given in the context (it can be \( A, B \) or some third set). Most \( A \equiv B \) is the case when the comparison is to the complement, i.e. More \( A \equiv B \) than not: \( A \cap B \neq A \). In general, a generic quantifier can be represented as a two-place relation \( R \) between two sets which satisfies certain axioms. These axioms restrict the range of variation of a generic quantifier between some and all and exclude outlandish interpretations (Zwarts 1983). These axioms bear an uncanny resemblance to choice function axioms.

There is a connection between genericity and vagueness. A vague assertion expresses an inclination, a preference to generalise in a given direction, without a pledge to adhere to the generalisation if there are counterexamples. This flexible attitude to meaning appears in many different sections of this book. I propose to attack vagueness in terms of comparative preference relations. Applied in this section, it amounts to treating generic quantification as a priority quantifier. It says that most if not all cases of \( A \equiv B \), as many as possible \( A \equiv B \). One is inclined to take any \( A \equiv B \), but also prepared to go back on the assertion in any given case.

In terms of priority Booleans, then \( A \equiv B \) might say something of the order of \( A \cap B = A \), or equivalently, \( A \cup B = B \). The spirit of this proposal is right, but the letter is not. What these forms say is just that one is prepared to pull back the generalisation entirely if there is a counterexample. This is right to the extent that one who makes a generic assertion is not shown wrong by one counterexample. What it misses is that one retreats from the generalisation case by case. One way to begin formalising this idea is to use lenient transduction:

\[
(A \setminus x : x)^\ast \ A \subseteq B
\]

What the quantifier \((A \setminus x : x)^\ast\) does is retract only as many counterexamples from \( A \) as is necessary to pull the inclusion through. In the best case, all \( A \equiv B \). In the worst case, none are. To raise the ante, the above formula can be conjoined to an absolute minimum, say most \( A \equiv B \).

Like any quantification, generic quantification lowers resolution by taking a quotient of the multiplicity of events out there. Ignoring all the colors in between, it leaves just black and white: either \( A \equiv B \) or no. Unlike absolute quantifiers, it buys back some of the flexibility through the use of a preferential truth definition. If the generic assertion fails, one is prepared to go to the cases.

Genericity affects all sorts of quantification. Plural and mass nouns are subject to it. The boys ate the soup can mean Some of them, many of them, most of them, or all of them ate some, a lot, most, or all of the soup. Aspect and modality can be generic too. It was noted earlier that It rained yesterday is vague about the proportion of rain in yesterday. A habitual sentence like He smokes can mean anything between he sometimes smokes, he often smokes, he mostly smokes or he always smokes. A conditional like If you drop them they break can mean they may break, they tend to break, they probably break, or they certainly break.

Existence for a token is to be somewhere (in a place at a time). Boolean meet marks existence: \( A \equiv B \) meet at \( C \) when they have parts in the same place \( C \). Types are in many places and times, or nowhere in particular. Interestingly, the dual (converse) relation of token existence \( A \equiv B \) is typically an atemporal generic event type \( B \) includes (contains) \( A \). The type-token duality shows up in the contrast between ‘universal’ and ‘existential’ generics Firemen are intelligent/available or Firemen must/can be intelligent.

**Countability**

Countability has since Aristotle been one of the archai of ontology. It comes up in different guises in the mathematics of natural language.

Noncount, including plural, domains have the structure of a Boolean algebra, while singular count domains don’t. In particular, they are not closed under complement, because they have shape, which is a topological property. Topology is
not preserved under complements. The complement of a simply connected region of a given shape is in general not simply connected or the same shape.

The plural-mass distinction corresponds to the distinction between atomic and atomless Boolean algebra. Every finite Boolean algebra is atomic. The Boolean algebra of the power set of a set is complete and atomic, and vice versa.

In topology, countability, or divisibility, comes up as the distinction between discrete and continuous. Discrete topology is the special case where the open-closed, point-region distinction vanishes and things become countable.

The count-noncount distinction thus really contrasts singular count objects against mass and plural objects. Looking at the distinction in terms of operators or contexts, we can consider the indefinite article a/n as a count operator and the absence of an article a noncount operator. Contexts that select for noncount nouns coerce the application of Moravcsik’s ‘universal grinder’: man tastes good.

In this section, I recapitulate well known analogies between the temporal and nontemporal domains which affect aspect. Quine (1960) takes it as one of the defining features of noncount objects is that they have cumulative reference, i.e. closed under a (physical or logical) join operation. Two measures of water combine into a larger measure of water; two sets of birds combine into a larger set of birds. The property of cumulative reference reflects the way how noncount objects are defined or identified: they are shapeless and homeomorphic: the whole is similar to the parts (Aristotle). Given a mereology, for instance a Boolean algebra on the nominal domain, various conditions can be stated for different types of noncount objects (Link 1983, Bunt 1985, Pelletier/Schubert 1989, Krifka 1989, 1990, Verkuyl 1993). The essential one for our purposes is closure under join: water and water is water.

\[
\text{water} \cup \text{water} \subseteq \text{water}
\]

Consider a simple weather predicate like rain. Rain can be looked upon as a spatiotemporally connected event of water pouring from the sky. There are three dimensions from which it can be viewed, the time it takes, the place where it happens, and the water that falls down. As a three-dimensional graph, it seems practically continuous and connected in all of its dimensions. Whichever way we split it, rain and rain is rain.

\[
\text{rain} \cup \text{rain} \subseteq \text{rain}
\]

In particular, rain can be plotted as a function of time: as time goes by, continually more water falls down, the rain may remain stationary or move ahead in a continuous fashion. From a Quinean point of view, the relation between event and nominal reference is not just an analogy, it is a property of (our view of) spacetime in all four dimensions.

Recall a topological definition for what it means for a space-time mapping to be continuous. A mapping between topological spaces is continuous if it preserves limits. The function cannot jump unexpectedly, be now here and entirely elsewhere in the next instant. Nearby positions must be reached at nearby times. This is tantamount to saying that the graph of the function is connected.

Neighborhoods are closed under joins. If the domain of a continuous function is closed under joins, the codomain is also closed under joins. This means that an event type which is a continuous mapping from time to an open object type is entailed to be an open event type. More generally, continuous mappings between spaces preserve topological properties. This is the essential content of the dependency of aspect on object type.

We can single out three important special cases of temporal continuity, (stationary) state, (continuous) motion, and (continuous) increase or decrease (growth).

**Number**


Boolean algebras are a good universe to define a contrast between total and partial reference (Link 1983, Chierchia 1998:75). Given a noncount denotation \( O \) with a free Boolean algebra defined on it, \( O \cup (\text{all of } O \text{ or the } O) \) denotes the top element (join) of \( O \) The inverse operation \( \text{pl } O \text{ (some of } O) \) for a count denotation \( O \) denotes the free Boolean algebra generated by \( O \). A sequence of \( \text{pl } O \) and \( \text{pl } O \) reduces. This will imply in particular that in a fixed universe of discourse, some of the mer \( \text{pl } \text{men} \) will denote the same as men.

A bare nominal unmarked for number can be taken to denote a generic noncount object algebra of this kind, as in kick ass or change shirt. These describe types of activity, instantiated by kicking individual arses or replacing one shirt with another. Many languages have grammatical means to incorporate generic nominals with activity verbs to produce generic activity types (Lapolla/Van Valin 1997:124).
More precisely, \textit{pl man} is the Boolean algebra \(2^{\text{man}}\) minus atoms and null, or \(2^{\text{man} \cup \emptyset}\). (Removal of zero preserves closure under join but loses complementation, Link 19??, Landman 19??).

The denotation of the \textit{men} is the unit set of the top element \(\cup \text{men}\) of \textit{men} If the plural predicate are mortal similarly denotes the set \textit{pl mortal} of all pluralities of mortals, we get the right semantics for the \textit{men} are mortal as the intersection of the \textit{men} and are mortal: the \textit{men}\(\cap\)\textit{pl mortal}.

The denotation of the singular \textit{man} is the set of unit men. It is not a Boolean algebra. Its join \(\cup \text{man}\) only exists when there is only one man in the universe of discourse. In this case \textit{the man} has the trivial Boolean algebra consisting of the empty set and the one man. The singular \textit{every man is mortal} equals \textit{men are mortal} without the restriction to pluralities: \textit{the pl? men} \(\cap\) \textit{pl? mortal}. Every \textit{man} is equal is predictably odd, for it entails the singular \textit{man}\(\cap\)\textit{equal} provided \textit{man} is nonempty.

\textit{All men are mortal} is \textit{every man is mortal} in the plural, i.e. it means all \textit{sets of men are sets of mortals}: the \textit{pl men} \(\cap\) \textit{pl mortal} As predicted all is awkward with a collective reading of the plural: All \textit{people weigh more than all ants} (together). As expected I read all newspapers has open aspect. This generalises to other increasing quantifiers: most \textit{men} denotes the set of all majorities of men.

Nonincreasing quantifiers reduce to intersection one type higher than increasing ones\footnote{In general universal or \textit{pi} sentences translate to existential or \textit{sigma} sentences one type higher, Chang and Keisler (1973):}.

\textit{She sells exactly six sea shells} does not mean 'she sells a set of exactly six sea shells' but 'the set of sea shells she sells is exactly six': \textit{six}\(\cap\)\textit{the(she sells)sea shells}. Verkuyl's (1993) parade example \textit{eat three sandwiches} comes out as \(3\cap\)\textit{the(eat)sandwiches} which says that the intersection of the set of triples and the join of the sets intersecting sandwiches and edibles is nonempty. This makes compositional sense of \textit{at most} as well: \(\leq 3\cap\)\textit{the(eat)sandwiches}, cf. van Benthem (1986:52).

The event-object count ambiguity of Krifka's (1991) \textit{Four thousand ships passed through the lock} quantifying over ships or passages can be represented by \(4K\cap\)\textit{the(ships pass)} vs. \(4K\cap\)\textit{the(ships pass)}. Both readings are closed.


A key to a solution is that the denotation of of the \textit{singular} count noun \textit{set} is no longer the Boolean algebra of sets, but the class of \textit{unit sets}. An \textit{union} of \textit{unit sets} is no longer a \textit{unit set}. The denotation of a count noun is not open (closed under join). It is not the logical type that is crucial but the topological structure of the denotation. The bare plural \textit{sea shells} has the same Boolean algebra as \textit{sets of sea shells} but different from \textit{sea shell} or \textit{set of sea shells} which have the trivial one.

The puzzle with singular count nouns is repeated in numerals. \textit{She sells at least six sea shells} has a closed reading though \textbf{at least six} as a quantifier is monotone increasing. \textit{She sells at least six sea shells} seems to mean \textit{She sells a set of at least six sea shells}. This suggests analysing \textbf{at least six sea shells} as a singular quantifier a \textit{set of at least six sea shells}, which is not closed under join any more than a \textit{set} is.

Verkuyl (1993) points out that an open reading \textit{She sells six sea shells all day} is fine when \textit{six sea shells} is understood as \textit{six kinds of sea shells}. On this type shifted reading, even singular \textit{she sells this sea shell all day} is fine. Finnish provides grammatical support for the treatment. The specific (closed) and generic (open) readings of \textit{She sells six sea shells} are distinguished by the case of a singular numeral (nominative for the closed reading and partitive for the open one): \textit{Hän myy kuusi/ kuutta simpukaa}. 'She sells six (sg nom/part) shells'. The \textit{six sets} reading has the numeral in the plural: \textit{Hän myy kuudek simpukat/kuusia simpukoida} 'she sells six (pl nom/part) sea shells'.

**Type shifts**

Generic type shift creates open events more generally: \textit{The soldiers came to town regularly} can mean different sets of soldiers of the same garrison did at different times. Even in the singular \textit{For centuries, the mafia boss died in bed/was stabbed by a competitor} makes sense. (Verkuyl 1993:131). Note also the possibility to turn absolute frequency to relative frequency: \textit{She sells six shells per customer all day}. Relative frequency is preserved under joins.

The syntactic freedom in semantics gained by higher order logic is well known (Montague 1968, Benthem 1986). By shifting types, it is possible to get semantics conform to surface form. It is possible to reinterpret function argument relationships and turn universal to definite quantification. For instance, the ambiguity of \textit{every man} \textit{drinks some water} can be expressed in Boolean terms as the scope ambiguity \textit{the men (drink water)} vs. \textit{(the men drink) water}.
Downshift is not always possible. A definite nominal like the man is an atomic Boolean morphism. Somebody or nobody are not; in particular, they do not commute over complement: somebody ∼ p is not the same as ∼(somebody p). This generalises to plural. ∼(all p are q) is not all p are ∼q. A solution is to lift the universal quantifier all men one storey up so it becomes an atom the men. This quantifier is atomic with respect to second order properties. For instance, the men do not agree is true iff the men disagree is false: ∼(the men agree) equals the men ∼agree. This is a case of genericity in that the proportion of men that (dis)agree covaries (some, most, or all).

Ulysses’ second name nobody can be translated grammar true as the empty object type Ø and somebody as the object type 1. Nobody runs (faster than me) says Ø run which when expanded to Ø \{run > Ø\} only holds in the trivial Boolean algebra of one element Ø = 1. Its complement somebody denotes 1, for somebody runs 1 run expands to 1\{run > Ø\} which equals run > Ø. Everybody runs means the same as all run,. It is also denoted by 1 run but in the algebra 2 where 1 is an atom. In that algebra 1\{run > Ø\} iff 1\{run = 1\} alias run = 1.

Instead of quantifying the subject, the predicate can be quantified. What happens to lifted properties? For instance, all the people are black equals the people are all black where all black is a plural property. This is also bivalent: the people are not all black equals not all the people are black. Negative quantifiers are symmetric over be.

In the same vein, The people are partly black can be a restatement of part of the people are black. Or A lion may have a mane is a restatement of some lions have a mane. Consider also the ellipsis in

John plays poker on Fridays but not bridge.

The logic of the ellipsis comes out right by juggling the type of the nonelliptic premise to match the remainder:

∀ john ∼play \(1 \cap \) poker ∼bridge ‘The games John plays include poker but not bridge.’

**Plural**

Starting from Boolean algebras instead of sets makes the singular-plural distinction a secondary one instead of a primitive. The singular-plural distinction is the one-atom boolean algebra against atomic Boolean algebra. Many languages of the world treat the singular-plural distinction as an optional one or give it the grammar of measure phrases (Sharvy 1978).

Plural moves a type one level up in the type hierarchy, from atomic Boolean algebras isomorphic to 2 to algebras generated by sums of such. Plural pl man forms a Boolean algebra whose unit the pl man the men is the denotation of the singular man.

Using the for the unit set operator and pl for the power set operator, we can map the type hierarchy as follows.

<table>
<thead>
<tr>
<th>Formally</th>
<th>type</th>
<th>Description</th>
<th>denotation in</th>
<th>expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homer</td>
<td>e</td>
<td>Individuals</td>
<td>X</td>
<td>Homer, the man</td>
</tr>
<tr>
<td>Man</td>
<td>t/e</td>
<td>sets and properties of individuals</td>
<td>(2^X)</td>
<td>man, the men</td>
</tr>
<tr>
<td>pl man, the man</td>
<td>t/t/e</td>
<td>first (singular) quantifiers, plural properties</td>
<td>(2^2^X)</td>
<td>men, every man</td>
</tr>
<tr>
<td>pl pl man, the pl man</td>
<td>t/t/t/e</td>
<td>second (plural) quantifiers</td>
<td>(2^2^2^X)</td>
<td>sets of men, all men</td>
</tr>
</tbody>
</table>

**Table 60**

In particular, by lifting types is possible to reduce predication and quantification into Booleans. Homer is a man if Homer as a set of sets meets the unit set of all men, and all men are boys if the unit set of all men meets with the set of all sets of boys. Booleans distribute homomorphically when the types are right for it (Löbner 1990). For instance, the boys are awake or asleep entails the boys are awake or the boys are asleep collectively, i.e. when the boys is a plural term satisfying plural predicates awake/asleep so that the logical form of the sentence is the pl boy ∩ (pl awake ∪ pl asleep), not distributively the pl boy ∩ pl (awake ∪ asleep).

Plural sentences are generic (Carlson 1977) in that pluralities are thought of, visualised and related as individuals. They have a vague and negotiable relation to sentences about individuals. Truth for plurals is generic just as much as for the singular.
Plural distributivity

The distribution of plural into singular is an instance of genericity. It applies equally to monadic types and to relations. *The dishes are clean* requires that every dish is clean, while *the dishes are not clean* only requires that one dish is dirty. *The guests know one another* may require that every guest knows every other guest. *The telephone lines touch the trees* may only require that one line touches one tree.

In general, the distributivity of the plural into the singular depends on the event (or rather, object) type. This means that plurals are distributed according to the implicit quantifier character of the predicate diathesis (Löbner 1990). Distribution depends on the quantifier character of the relation, because the same Boolean definition is applied to nonatoms as to atoms. Distribution laws are not another thing over and above the definition of the relation.

We should not say that Jews are shifty if one jew is shifty, but we can say that jews have invented relativity if one jew has. So some relations are preserved under extensions, and they are existential. Some are preserved under submodels, and they are universal.

Existential properties are preserved under extension of models, like dirty. Universal properties are preserved under submodels, like full. Many are of the generic mostly type, like the sky is blue, or people are selfish, they are not preserved under submodels or extensions. Universal-existential properties are preserved under arbitrary unions and finite meets (Chang/Keisler 19??) Compare the upward monotone and conjunctive properties of classical (regular) modal logics (van Benthem 1986:193).

In terms of Boolean relations, distributivity concerns what it means for a non-atom to have a relation to another non-atom. For instance, what does it mean for us to beat them? It can just mean that our army beats theirs. Or it may mean that our best guy beat theirs. It may or may not mean that each one of us and them is involved or takes part in the fight. Perhaps every one of us beats some one of them and every one of them is beat by some one of us. The strongest condition is that everyone of us is better than everyone of them. (These alternatives may be compared to the ways to order periods in the section on order.)

The strongest distribution condition is that the relation forms a Boolean homomorphism, i.e. distributes over joins meets and complements. This entails that everyone loves everyone, i.e. if A and B love C and D, then A loves C and A loves D and B loves C and B loves D. The relation distributes to the universal relation or cartesian product of the field. This happens if the relation only makes sense of individuals. We usually think know distributes because we think of knowledge as an individual thing. This is not always true, we can know things together, like the combination to a safe.

The weaker condition is that every member of a plurality is somehow involved in the event. One reading of involvement is that every member is in the field of the relation. This version of the distribution principle is of the universal-existential type: every x in a is in r to some y in b, and every y in b is in ~r to an x in b. The relation r is weakly connected.

Why should weak connectedness be an important distribution principle? What sort of relations are weakly connected? Here is one central case. The logical form of a transitive event type a p cause b q is that there is an event a p which every x in a helps bring about, and whose outcome is the event that b becomes q, in which every y in b is involved.

Causal event types imply weak connectedness. A causal event type is a composite of two monadic event types p and q inside. If both p and q distribute separately the result is just that the field of the the cause relation includes the atoms of p and q.

But even that is not necessarily the case. It is quite possible for us to beat them without anyone beating anyone. Perhaps a together cause an event which causes b to scatter. Nobody does anything alone, only the whole band of a beats the band of b. In this case, no one need be in the field of cause, it is enough for everyone to be involved. For that it may be enough to belong to us. Thus cause need not distribute to the singular. Even if one must help, or be a necessary part of a sufficient cause, nobody need be a sufficient cause of anything.

Or take we do the dishes meaning I and you wash and dry. What does this distribute to? It would not be fair to say this if one of us does nothing, or if the dishes do not get done, but that is about it. Otherwise we can share the labor any way we like. The event type wash and dry is a Boolean relation between a cause we and an effect they dishes get done. The constraint on weak connectedness falls out from the contingency requirement on causation, an instance of the maxim of quantity. If we do the dishes is not atomic, but includes a smaller event type like you do the dishes, why not say so. Distributivity will come up again with reciprocals.

Plural reflexive

Consider plural relations like the clients stand in a line, the men are having a fight, the molecules collide, the kids share a room, we are a big family. Logically, it is unfair to ask which is the more primitive relation, the plural collective one or the singular binary one. Being related to something is being in a relation with something. Lexically, the plural relation can be primitive, the singular binary relation missing or derived. For instance, a contact, a fight, a configuration can be the starting point, and the binary relation, if any, a causative of involvement in one. There are plural verbs like
Finnish tapella, which do not even have a transitive singular. The common structure is a universal relation $x$ in $z$ or its binary special case, the symmetric relation $x$ and $y$ be in $z$.

Natural languages make special dispensations for expressing reflexive and reciprocal relations. A common denominator between them is that both define endomorphisms, i.e. include codomain into domain.

A plural reflexive relation denotes a join of universal relations ranging between universal relation (We are all related) through weakly connected relations The monkeys are grooming to the identity relation (we all love ourselves). Whether the plural reflexive distributes and how depends on diathesis. Compare We see ourselves in the mirror (everyone sees all?), or The passengers of the ship saved themselves.

The reflexive diathesis change from $x$ wash $x$ to $x$ wash is an unmarked application of the copy combinator $C$ licenced by a coincidence with the projection combinator $K$. It applies in singular as well as plural: $I$ wash means $I$ wash myself. The plural does not take stand as to how we divide the labor: in we wash (ourselves) lets me wash your back and vice versa, as long as it stays in the family. The same transformation thus covers reciprocals as well: We fight we fight means we fight we fight ourselves or We fight one another. This diathesis change is available for reflexive or symmetric event types like marry, meet, fight. The connection is that symmetric event types are plural reflexive: I meet you so you meet me, hence we meet us.

$$(I$ meet you$)$ and (you meet $I$) = (I and you) meet (you and I) = we meet we = we meet

The fact that $C$ is unmarked for symmetric event types is no surprise since the second copy of the variable is predictable from symmetry.

The way plural distributes to singular depends on diathesis. This variation is a case of genericity. The event type men die is a generic statement ranging from some men die to all men die. all men die means the same as the men die (modulo definiteness or genericity).

Reciprocal

One difference between reflexive and reciprocal is that reflexive has both numbers (singular or plural), reciprocal is inherently plural. A reflexive relation $r$ satisfies xrx which means that the diagonal $1_r$ is included in $r$. A reciprocal relation is irreflexive, i.e. satisfies $\neg xrx$. So reflexive and reciprocal relations are disjoint. When plural pl is continuous in $r$, so that distributes into singular by the rule $(pl \times) r (pl \times y) = pl (x \times y)$, reflexive and reciprocal relations are also complementary, and the reciprocal relation pl1 is symmetric and almost transitive, i.e. $xry$ and $yrz$ entails $xrz$ or $x=z$.

We are married can mean we are married to one another or we are both married to someone else. The two fall together in a domain of two, where they mean we are married between ourselves.

A reflexive plural where the plural relation which distributes into an irreflexive symmetric singular one is reciprocal. The biggest reciprocal relation is the difference of the universal relation and identity $I\phi$, for instance The numbers are all different. All of my relatives have never met may mean there has never been a family reunion. A smaller one is an order relation The numbers follow one another where the symmetric closure of follow is weakly connected. An even weaker one is The gas molecules bump into one another. The houses are near one another may or may not suggest the outermost houses are near one another.

Plural irreflexive is a source of injective mappings like days follow one another. (Westerståhl 1989). A related source is different. We are all different means each one of us is unique. The hats are different defines an injection, so that The men wear different hats entails as many hats as there are men. As long each wears just one, this is first order Women own different hats might assert the existence of an unidentified injection. (I am not sure it does.)

Compare also all men are similar (in some way or other). It is taken to mean that some property is shared by all rather than that any two men are similar. Not surprisingly self-similarity is excluded, just as it is in I am similar.

Involvement in a collective relation ranges from just belonging to the collection to being individually related to every other member of the collection. The guests know one another may mean that every guest knows every other guest. The people killed one another means that every one got killed by someone else. The numbers correspond to one another one to one says what it means. The telephone lines touch one another may only mean that one line touches another. There is nothing contradictory about a reciprocal of a linear order: Days follow one another. (Cf. section on Tagalog.)

It is rather obvious what one another or each other want to say. We fight each other means we fight (among) ourselves, each one of us another of us. Each other is originally an apposition to an implicit reflexive we fight, each other. What each other defines is not just an endomorphism but a mono, an injection where no one is mapped to themselves.

\[198\text{Finnish uses plural nominative Naisilla on eri hatut when there is a unique injection between women and hats. Plural partitive Naisilla on eri hattuja entails no injection at all. This makes me suspect.}\]
For irreflexive relations \( r \), reciprocal is equivalent to a plural reflexive: \( A \text{ and } B \text{ envy } A \text{ and } B \) means \( A \text{ envies } B \text{ and } B \text{ envies } A \). The plural reflexive of an irreflexive relation is reciprocal. This explains why reflexive in many languages does duty for reciprocal: \( \text{fr se battre, ru bit'\text{j}a} \) ‘fight (one another, i.e. among themselves)’, Melchuck (1993:§4.3.5).

**Iteration and distribution**

The Kleene regular iteration operator is a noncommutative plural. It orders a plurality of events of a given type in a sequence. This is a generalisation of the equation \( t.u = t+u \) relating concatenation with Boolean addition.

Serial frequency adverbials can be represented as concatenation powers. However, there are arguments to show that frequency adverbials like \textit{twice} quantify events on other dimensions as well. One can break an arm twice at once in two different places. Time and space may not suffice either: one can be insulted twice by one insinuation. A more general treatment of frequency adverbials is obtained by basing event counts on Boolean addition instead of concatenation product.

Distribution entails a morphism between two domains. In natural language, the term usually denotes a morphism between two domains. Witness etymology: \textit{als} continuity (van Benthem 1991:243). Iteration is distribution of the common fixpoint of the quantifiers.

There is a neat duality between the Russellian existential-universal first order quantifier characterisation of uniqueness and a definition of uniqueness as a minimax operator on sets. Recall that \textit{men} or \textit{pl man} denotes the power set \( 2^{\text{man}} \) of sets of men. \textit{The men} is the maximal or unit element of this algebra \( \cup \text{men} \) which equals the denotation of \textit{man}. By the definition of maximality above, \textit{the men} is the maximum of \textit{men}. The maximum is unique if it exists.

Now take the plural denotation \textit{men} as primitive. Its meet \( \cap \text{men} \) is nonempty if and only if its join \( \cup \text{men} \) or \textit{man} is a singleton, in which case it again has the minimal one-atom Boolean algebra \( 2 \), in which it is a minimum and a maximum at once. Thus we can dually define \textit{the man} or \textit{one man} as \( \cap \text{men} \).

The quantifiers \textit{some} and \textit{all} are dual. Unity \textit{one} is where they coincide and degenerate to identity, so that \textit{one} is the common fixpoint of \textit{some} and \textit{all} where \textit{some men} = \textit{all men}. Witness etymology: \textit{some} and \textit{all} fall together when \textit{an}
(≤ one) only (≤ onely) one is alone (≤ all one) or lonely (≤ all onely). In natural language, this shows in the fact that bare noun phrases have unique (definite or generic) reference.

The Boolean algebra of an atomic Boolean algebra. Recall the characterisation of singular count (closed) event types in terms of the negative condition that b is not of the same type as b. This can be rephrased as the condition that b is an atomic event type, or as the definition of atomicity says above, the only part of a b that is also b is the same b. The only way for an atomary (singular closed) event type to form a Boolean algebra is to be a one-member algebra 2.

It used to be an article of faith that “strong” do not go with existential there. There is no reason not to assume that there is x more or less literally means x be there, with there a free variable over places. Then there are all men means the same as all men are there, which is logically true, and there is me means I am there, which also says nothing (Westerståhl 1989:39). This is all simple enough. As is also well known, the article of faith is not entirely true, for there are other uses for the subject-predicate inversion in sentences like

There are the people who always know better.
There is every reason to believe so.
And then there was you.

Why one man but not one water? The question is badly put, for one water can be one glass of water or one kind of water. Indefinite article a man is a weakening of one man to at least one man. As types of object types one man, a man and man are almost the same thing, but not quite. What one man entails on top of the others is that number makes no difference: man=men. Here men denotes the Boolean algebra of men. man denotes the sum of its atoms, the unit of men. man=men is nonempty just when men is the trivial one-element Boolean algebra. By the same token, one water is nonempty just when water denotes a sum of atoms.

one can be typed as a determiner which turns man into a relativised Boolean quantifier that denotes 1 for come just when man come is a trivial one-element Boolean algebra (van Benthem 1986, Westerståhl 1989). Besides this and other surface true ones, One man came has the event types

\[ \text{man come} = \text{men come} \]

\[ x: \text{man come} \cap y: \text{man come} \subseteq x=y \]

\[ (\text{x be man who come} \cap y \text{be man who come} \rightarrow x=y) = 1 \]

The subject relative who eor that e is English grammar for abstraction 1 e.

### Only

In typological view, quantifier grammar is polymorphic. The Aristotelian syllogistic quantifiers all, some, no are usually studied as determiners or (subject) noun modifiers. Besides that quantifiers appear as independent (pro)nouns take some and as adverbials (“floating” quantifiers) you are all here. The quantifier only (van Benthem 1986, Westerståhl 1989:53, Rooth 1992) is adverbial in form and distribution in you only have to try, but in construction with the subject noun in only you came. Etymologically only is the adverbial form of one. Logically, only seems to entail at most one and implicate at least one.

The fact that only is a predicate modifier (or perhaps rather, not only a subject modifier) is motivated by its being the relation dual or converse of all. Only men allowed means all allowed are men. As an inclusion quantifier, it does modify the prediate and not the subject. A good paraphrase is those allowed are at most the men the allowed \( \subseteq \) the men. or more boldly those allowed are just the men the allowed = the men. The difference between inclusion and equivalence is the existence implicature of only.

Generally, we can treat only as a contextual uniqueness quantifier on event types. In the simplest case of one-place event types it only rains has the grammar true logical form rain = 1. The contextuality of only concerns the choice of algebra whose unit 1 is. Here it might be just rain∪rain. She only smiled she smile = 1 makes one think of all the other things she might have done: she smile = p:sh e p. Only men allowed it fits this mold too by setting 1 = allowed to get the inclusion men allowed = allowed. This analysis also matches the common paraphrase of only e by e (that) is all.

### Equilibrium

A game equilibrium is a minimax solution of a game. In general, an equilibrium is a two-way minimum, or or saddle point. Uniqueness, up to an equivalence class, is involved here too.

One way of characterising equilibrium is to say that some absolute or relative difference (differential) is 0. This entails that two quantities of opposite sign are equal. A stable equilibrium involves two things:

- at a point of equilibrium, two opposite quantities (functions) are equal, which means that they sum to 0.
the equilibrium point is an extremity for both quantities, a minimax or saddle point so that at nearby points, the differential (vector) of both quantities points to the equilibrium point.

The equilibrium is stable in that the system returns to the equilibrium from (sufficiently small) disturbances, i.e. from points in the neighborhood of the equilibrium.

This explication of equilibrium relates it to the concepts of maxima and minima. Conversely, we may expect that there is an explication of the latter in terms of the former. And there is.

Using game-theoretical semantics, we can explicate the notions of equivalence and uniqueness (up to an equivalence) as equilibria of simple two-person zero-sum games of matching.

Say there are two properties, \textit{man} and \textit{white}. One player \textit{I} chooses men and another \textit{you} chooses whites, independently (in ignorance of) one another. Thus the game is one of imperfect information. I win if our choices meet, you win if they don't. It is easy to see that I have a winning strategy in this game if and only if \textit{man} and \textit{white} are equivalent. The winning strategy is to choose the set of all men.

The game of matching creates a connection between equivalence and uniqueness. The identity matching game connected with \textit{the men} is the same as the matching game, only both players choose sets of men. I win by choosing the set of all men. In the singular game with \textit{the man}, atomicity of individuals entails that our choices meet only if they are the same. Thus uniqueness is equivalence up to identity, the finest congruence.

There are more complex versions of the matching game, known as Fraissé-Ehrenfeucht games or bisimulation games, which capture the semantics first order quantification to the dot.

Comparison

The section on order laid out a dense net of morphisms between different ways of denoting order in formal and natural languages. Looking at natural language, binary comparison is a marked option. The unmarked form of an adjective is the positive form. In all of its forms, a comparative adjective can be taken to denote a choice function. The degrees of an adjective indicate the choice set from which the choice is made.

Despite its monadic form, the positive adjective is a projection of a two-place relation (a one-place function). The absolute or positive form like \textit{big} and \textit{small} mean relatively big or small, or bigger and smaller than some \textit{norm}. The same object is at the same time big and small when it is between two extremes. (This was a familiar puzzle for the classics). Formally,

\[ x \text{ be big } p \]

entails but is not exhausted by \( x \text{ be } \text{big} \) and \( x \text{ be } p \). The relation of \textit{big} and \( p \) is not meet, but a composition, or fibred product under the constraint that the choice set of \textit{big} is \( p \). The logical form of \textit{big } \( p \) is something of the order of \( \text{big} \_\cap \_p \). In this case, \( \text{big} p \) and \( \text{big} q \) can be independent for independent \( p \) and \( q \).

\( \text{big in } p \) can be construed as a restriction of the choice function of \textit{big} to the domain of \textit{in} \( p \). In this case, \( \text{big in } p \) is entailed by \( \text{big} \_\cap \text{in } p \) but not vice versa.

When is an object big in a choice set? This is a generic event type, so the usual rules of generic attributions apply. An object is big in comparison when it is rather big than small. If sizes follow normal distribution, a big one belongs to the bigger half of the set, i.e. is \textit{bigger than usual} and \textit{bigger than most}, but not necessarily \textit{biggest of all}.

A side profit of the choice function representation of comparison is that it makes formal sense of the notion well known to linguists that repetition increases intensity. Boole (1858:32) points out about \textit{good, good} men that “such repetitions of words are indeed sometimes employed to heighten a quality or strengthen an affirmation”, but considers it a “cumbersome and useless pleonasm”, “not founded in the intrinsic relations of language and thought.” I gave a pragmatic explication of how repetition may strengthen an affirmation in Carlson (1983:122-123). Choice functions explain how repetition may serve to increase intensity. If good is a choice function for a preorder, \textit{good good \subseteq good} but not necessarily vice versa. The good good men may be better than good men.

Comparative

The comparative \textit{bigger} can be considered a grammatical dual number form of the positive, as its Indo-European etymology attests. In many languages, \textit{than} is a source case, indicating the negative end of the comparison. The direction is from the small end to the big end. If comparative means \textit{more}, comparison then matches the event type of incremental growth \( \text{e} + \text{e} \) where \textit{more} is a sum or increment operator \( \text{e} + \text{e} \). The use of the case marking then allows the word order to invert to the preferential order of biggest first.

English \textit{bigger than} orders \( x \) and \( y \) by decreasing size, for English \textit{than} is a variant of \textit{then}. By preference the big one comes first, then the small one \textit{more e>e}. 

\[
\begin{align*}
\text{x be big } & p \\
\text{big in } & p \\
\text{big in } & \text{man}
\end{align*}
\]
bigger is the big one of two unequals, while the other is the not big one, or the small one. There are languages which lack comparative morphology and express comparison in just this way: x is bigger than y is phrased x is big and y is not big. The same strategy is followed in child language (Clark/Clark 1977). The event type

\((x \text{ be big } \cap y \text{ be } \neg \text{big}) \text{ in } (x \text{U} y)\)

is in fact one valid event type for binary comparison. There are other good alternatives, for instance \(x \text{y } \cap \text{bigger}\) which says that the sequence \(x \text{y}\) can be embedded in the weak order defined by \(\text{bigger}\).

The main difference between positive \(\text{big}\) and comparative \(\text{bigger}\) is where the norm is sought. The comparative is logophoric, so the norm must be located in the preceding discourse. Compare the text you are big and I am big with you are big but I am bigger. It is likely that the comparison is between you and me in the latter case.

**Superlative**

The explication of comparative above gives a good avenue into the superlative biggest: it denotes a suffix of the bigger relation. A least three things must be compared to make a difference between positive, comparative and superlative: he is big, you are bigger, I am the biggest. Big members of a choice set are bigger than most, while the biggest members of a comparison are bigger than all the rest.

Superlative is marked in Finnish with plural morphology \((\text{iso } \text{big} \text{ } \text{iso-mpa } \text{big cmp} \text{ } \text{big pl cmp } \text{biggest})\). In many languages, superlative is distinguished from comparative with the definite article. Note that the definite article appears also in English. The discussion of the previous section explained why: maxima are unique up to equivalence in virtue of transitivity of comparison.

**Positive and vagueness**

The difficult thing to capture about positives is their vagueness (Fine 1975, Kamp 1975, Klein 1982): just what does it mean to say that something is small? My answer can be termed in priority closure: as small as necessary or possible.

The positive small is the positive priority composition closure small\(^\omega\) of the binary relation small. Choice of an exponent of the iteration corresponds to choice of a norm of comparison.

This is different from saying that the positive small is the existential closure of the relation smaller, or that it is smaller with a free indexical variable for a contextual norm. It says that there is a freedom of choice for the norm, but that the norm defaults to as small a value as possible in the context. It ensures that small objects in the context include the smallest objects in that context, i.e. they form a prefix of the sequence. smallest entails small and small entails not large but not vice versa.

For another application of this characterisation, take the ordinary language definition of continuity of a function:

A small change in \(x\) causes a small change in \(y\).

This is a generic claim through and through: the TMA form is generic, the adjectives are in positive form.

The usual explication of continuity involves three quantifiers: for any change in \(y\), as small as possible, there is an \(x\), as small as necessary, so that any smaller change in \(x\) causes a smaller change in \(y\). Natural language gets by with none. How can it indicate a complicated quantifier condition?

By the natural language formulation, \(y\) is continuous in \(x\) if there is a way to choose \(x\) as small as necessary so that it causes as small a change as possible, in \(y\):

\(\text{gen } x: x \text{small}^{?}\text{ cause } y: y \text{small}^{?}\)

The generic aspect is an existential-universal quantifier over strategies, cause stands for the function, and the composition closures provide the rest of the quantifiers. I choose a strategy at gen, and the size of \(x\) at \(^?\). You choose a strategy at gen and a size at \(^?\).

There is an alternative characterisation of continuity in terms of distributivity of complete join. A function \(y:x\) is continuous if \(y: \text{U} x = \text{U} y : x\), which says that the smallest \(y\) for any \(x\) are the \(y\) for the smallest of them.

**Good**

The relation of the adjective and the norm is intensional for good, so nothing can be inferred from good \(p\) to good \(q\) on the basis of the extensions of \(p\) and \(q\) (Geach 1956, Kamp 1975). It is not difficult to define subjective goodness: an agent prefers what seems good to him. By definition, we seek good things, avoid bad things and don’t care about indifferent things. The difference between like and want seems analogous to that between good and best. One may like many things, but what one wants is what seems best. The comparative better is verbalised as prefer.
Objective goodness is harder to make sense of. Quine (1960) suggests turning the definition round so as to define good for one as whatever one is pulled to and clings to. But preferences, like forces, are hypothetical, counterfactual event types. Further ethical problems concern resolution and measurement: how long times and how large coalitions of players to integrate goodness over, and how to sum goodness in the first place.

The dynamic analogy between inanimate and animate nature extends from driving forces to obstacles. Good things may be hard, heavy, or expensive. They take as well as give.

Measurement of meaning
The category theoretic and Boolean notion of duality is a mathematical and logical intuition at heart. It has a strong sway on imagination too, linguistic and otherwise. Entire religions have been based on duality. Look at the connotations of the following pairs:

<table>
<thead>
<tr>
<th>and</th>
<th>or</th>
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<tbody>
<tr>
<td>universal</td>
<td>existential</td>
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<tr>
<td>strong</td>
<td>weak</td>
</tr>
<tr>
<td>necessary</td>
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<td>certain</td>
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<td>have</td>
<td>not have</td>
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<td>one</td>
<td>many</td>
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<tr>
<td>positive</td>
<td>negative</td>
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<tr>
<td>big</td>
<td>small</td>
</tr>
<tr>
<td>rich</td>
<td>poor</td>
</tr>
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</table>

Positive or negative is not uniquely associated with many antonym pairs, not surprisingly given the self-duality of complements, games and equilibria, but they polarised all the same. Comparative order relations in general raise ambivalent feelings, like big and small. Control and freedom are ambivalent about goodness, so are many others. What is good for one player may be bad for another. Osgood et al. (1957) measured attitudes to antonym pairs on polar scales attitudes to and applied factor analysis to the results. They labeled the first three factors they came up with good/bad, strong/weak and active/passive. All three are game theoretic notions.

Measurement
Measurement involves partitioning and sums (Krifka 1998). Extensive measurement divides up an event into adjacent nonoverlapping successive subevents of some given resolution and counts them. This is basically what it is to measure (Krantz et al. 1971). A measure is a map from the domain to reals. Sufficient closure properties must be applicable to the domain of the measure for a morphism to exist from the domain to reals. It follows that measurable domains are noncount.

A measure in general is invariant over linear transformations (choice of unit and origin). Counting is the special case of measurement where the origin and unit are fixed (0 and 1). It is possible to count the elements of a finite or countable Boolean algebra, only the count is exponential relative to the number of atoms. Counting an atomless algebra makes less sense, for the count is always at least countably infinite. With continuity, there are more elements than there are natural numbers.

On closer analysis, it turns out we can distinguish between no less than four independent algebraic conditions (Halmos 1974) related to counting and measuring: additivity or upward closure over sums, solvability or downward closure over differences, atomicity or the existence of atoms, and completeness (continuity). In a Boolean algebra isomorphic to the reals, all four conditions hold. Extensive measurement (the existence of an additive homomorphism to reals) requires additivity, solvability and comparability or Archimedean property (Krantz et al. 1971, Fishburn 1977). Activities satisfy additivity and solvability down to some resolution. States satisfy solvability in the form of atomicity (discreteness, countability) or atomlessness (density, continuity) depending on the topology of time.

Grammatically, measure phrases are plural count noun phrases like two miles of form \( q \ m \) where \( q \) is a numeral (quantity) and \( m \) a measure (unit). Semantically, measures are indifferent about unit, i.e. \( q \ m = k^* q \ m/k \) for any other measure \( m/k \). 2.2 pounds can be replaced with one kilogram without change in truth value.
In the section on adverbials of duration, I proposed an analysis of measure phrases which ties in nicely with the notions of atomicity, extensive measurement, and granularity. A measure phrase like Two pounds of oats 2 pound of oats denotes a join of a proper coveror partition of oats of suitable resolution, so that oats is true of each member of the cover as well as of their join.

The measure phrase q m is a quantifier which denotes a class of partitions of objects whose sum equals q m. The object type q m of p equals q m ∩ of p where of p is the part algebra 2^p of p. This entails that a measure phrase q m takes a plural or noncount argument.

Measure phrases bridge the difference between count and noncount domains by providing units of counting. Many languages do not have morphological plural but use measure phrases in count domains after the model of thousand head of sheep. The units of counting are known as classifiers. Conversely, one could look at morphological plural as a syntactic measure term.

Metrics

A metric is a measure of distances, or a difference measure. A metric satisfies three conditions which generalise the reflexive, symmetric and transitive conditions of an equivalence relation. A triangle equality which says that the direct route is the shortest. In particular, the distance from x to x is minimal, so it can be 0. Third, the distance back and forth is the same.

\[ d(x,x) = 0 \]
\[ d(x,y) = d(y,x) \]
\[ d(x<z) \leq d(x<y)+d(y<z) \]

Behind the metric, there is a comparative notion that allows comparing sequences of at least three places.

\[ x \leq (x<y) \]
\[ (x<y) = (y<x) \]
\[ (x<y) \leq (x < z < y) \]

Transitivity is the special case of metric where equality holds so the distance is the same along all paths. Conversely, when equality fails we have a similarity relation where indifference of comparison holds inside a neighborhood of some size.

Events as objects

Tagalog moves between nominals and verbs fluidly. In nominals, pa is a deverbal object nominaliser what (is Ved), pang an instrumental nominal what (is Ved) with, pag a genitive or subject nominal whose (Ving), an a locative one where (it is Ved) . From from kausap 'converse, interlocutor' we get nominals like usapan 'where it is conversed, conversation', pangungusap 'what is conversed with, sentence'. From tawag 'name, call' katawagan 'what one is called by, title', from tanuw 'view' tanawin 'what one views, view'. The challenge here is to capture the common denominator of both perspectives.

Take tanawin for instance. As a verb, it means 'is viewed'. As a nominal, it means 'what is viewed', a view. The difference is that between that x is viewed and x that is viewed. These event and object types are equivalent in the sense that one is nonempty just when the other is. In denotation, they are just one lambda conversion away from one another. The event type is _view_, the object type is _view'_.

view_ ∩ it it is viewed
view'_ ∩ it it is what is viewed

From this distance, then, the difference between the finite event and the event nominal is one of focus or perspective. The first one speaks about the event, the second about the object.

New vistas open up from here. We can systematically go through the referential systems of nominals and verbs and look for further analogies entailed by this isomorphism.

Events as functions of time

Events which imply no change are constant functions of time. Constant functions are a trivial case of continuous functions. As expected, event types which do not change anything are open. This includes states and state causatives (maintenances) as well as transitives with an affected object.

Consider an event type like add one. It might be described by a formula like

\[ x = 0 . y = 1 . (z = x + y . x = z) \]
On one reading, this is an inconsistent event type, for \( x \) cannot be 0 and 1 at once. This happens if \( x \) cannot change with time. Compare Montague’s example \( \text{The temperature is 100 and rising.} \) One hundred cannot rise, but temperature can, because it varies with events. (This is the sense in which Heraclitus’s river is the same and different at once.)

Allowing for objects to be functions of events, there is another reading of \( x = y \) at \( t \) besides \( (x = y) \) at \( t \) namely \( x \) at \( t = y \) at \( t \). Then the event type \textit{add one} can be instantiated consistently:

\[
\begin{align*}
x & = 0 . \ y = 1 . \ z = x + y . \ x = z \\
x \text{ at } t = 0 . \ y \text{ at } t = 1 . \ z \text{ at } t & = x \text{ at } t + y \text{ at } t . \ x \text{ at } u = z \text{ at } t \\
0 & = 0 . \ 1 = 1 . \ 1 = 0 + 1 . \ 1 = 1
\end{align*}
\]

The last line is logically true.

Vlach (1993) observes that the property of \textit{constancy} itself is \textit{not} monotone (closed under joins). His example is \textit{regularly}. An event which is regular relative to a given scale may not be regular relative to a finer or coarser resolution. For instance, a heart can beat with a pulse of 60 at rest, rise to 120 walking and to 200 running; it is regular within each mode of locomotion but not regular throughout the journey. \textit{Regularly} and \textit{often} are related but logically independent. \textit{Often} classifies relative frequency, the first derivative of absolute frequency, \textit{regularly} in turn often means constant relative frequency.\(^{199}\)

Vlach’s observation becomes obvious when one notes that \textit{constant} means \textit{the same for all}. \textit{Constant} thus has existential-universal form: \textit{there is} a value of a dependent variable which is the same for \textit{all} values of an independent variable. It is a result of model theory (Chang/Keisler 1973) that first order existential-universal formulas are not preserved under joins.\(^{200}\) This observation explains why, or in what sense, \textit{regularly} is not an additive property. For \textit{regularly} says that \textit{there is} a rule which covers \textit{all} cases. If we fix the rule by which an event is regular, we have additivity; if we let it vary, we lose it.

**Comparative change**

Inclusion is a special case of a comparative relation, or a partial order. A comparative relation which can mapped continuously on time produces open/closed aspect entailments (Krifka 1998).

A comparative relation is a partial order, i.e. a transitive or acyclic relation. A partial order is extended to a complete (weak) order by requiring that the complement, the indifference relation is also transitive (Fishburn 1977), which makes it an equivalence relation. Finding its indifference curves is a step in mapping a comparative relation on a measure (Krantz et al 1971).

It has been repeatedly pointed out that the positive and comparative forms of adjectives are interdefinable using the function representation of binary relations. One can define the positive as the codomain of a binary comparative relation (\textit{much is more} than a norm); conversely, the comparative can be defined from the positive by restricting a choice function to two-element sets (\textit{more is much/most of two}) (Lewis 1970, Kamp 1975, Fishburn 1977, Dowty 1979, Klein 1982, van Benthem 1982, Landman 1991, Zacchi 1998).

Comparison is involved in comparative change. \textit{Grow} or \textit{increase} mean \textit{become more}. Aspect tests show that comparative change is open. To explain this, we should show that the concatenation \textit{more and more} entails \textit{more}:

\[
\begin{align*}
\text{more} & = \text{more}\uparrow \\
\text{more.more} & \subseteq \text{more}
\end{align*}
\]

If \textit{more} were an absolute change, this would not look at all obvious. A positive change \textit{grow up} (\textit{get big}) is closed, because one cannot grow up twice in a row (without becoming small in between). Chaining such changes in a row becomes at best an oscillating series. We must ensure that the second more starts where the first one leaves off. There is a multitude of ways of making formal sense of this. One suggestive derivation is to go back to the definition of \textit{bigger} as

\[
(x \text{ be big } \land y \text{ be } \neg \text{big}) \text{ in } (x \cup y)
\]

and turn this into an event type:

\[
(x \text{ be } \neg \text{big} . \ x \text{ be big}) \text{ in } (x \text{ at } t \cup x \text{ at } u)
\]

---

\(^{199}\) In general, \textit{regularly} means \textit{following a rule}; the rule may be more complicated than constant frequency.

\(^{200}\) Essentially the same logical point applies to ability type modalities (quod vide) and is why ability cannot be represented by a one-operator relational modality.
more is a relative adjective, so it denotes a comparative relation. What happens in comparative change is that the norm or choice set also changes with time. An \( x \) which is not more than some \( c \), or not much compared to \( y \), becomes more, or much compared to it. So we are really looking at iteration of absolute changes relative to a changing norm.

\[
(\neg c \lessdot x, c \lessdot x, \neg d \lessdot x, \neg d \lessdot x)
\]

What is the changing norm here? A very simple solution is to compare \( x \) to itself at different times. Then the event type for more more will become

\[
\neg(x \text{ at } t \lessdot x \text{ at } t) \land \neg(x \text{ at } u \lessdot x \text{ at } u) \land (x \text{ at } u \lessdot x \text{ at } v)
\]

This is not quite an instance of an absolute change: both ends of the comparison seem to be changing at each step. The difference is that the changing norm is a constant in time while the subject of the change is a variable function of time. This becomes apparent when the above event type is rewritten as

\[
\neg(x \text{ at } t \lessdot x) \text{ at } t <. (x \text{ at } t \lessdot x) \text{ at } u \land (x \text{ at } u \lessdot x) \text{ at } u <. (x \text{ at } u \lessdot x) \text{ at } v
\]

Leaving out the intermediate state and applying transitivity of comparison \((x \lessdot y \lessdot z \text{ entails } x \lessdot z)\), we can infer more, which says

\[
\neg(x \text{ at } t \lessdot x) \text{ at } t <. (x \text{ at } t \lessdot x) \text{ at } v
\]

This proves that a comparative change like \textit{grow} (get bigger) more is aspectually open. Many change verbs are vague about the distinction. Comparative changes thus constitute a large class of process accomplishments. The analysis of comparative change thus explains the ambiguous aspectual behavior of process accomplishments. Zucchi (1998) notes that a process accomplishment like \textit{bake a cake for an hour} does not entail the absolute (bounded) event \textit{bake a cake}. From the point of view of comparison, this is not surprising, for the comparative of an adjective never entails its positive: \textit{more} does not entail \textit{much}.

More abstractly, a preorder (reflexive and transitive order) can be represented as a set of ordered pairs \( x < y \), or equivalently, as a set of intervals (convex sets) \( x < y \) bounded by such pairs. Given transitivity, the relation (set of pairs) is closed under composition. Equivalently, the set of such intervals is closed under convex joins, i.e. is open.

A parametric representation of comparative change is a function from time to the dimension of change satisfying a conditional of form

\[
t < u \rightarrow x \text{ at } t \lessdot x \text{ at } u
\]

That this formula represents an event type true of any period of sustained (monotone) growth in \( m \): Any period starting in \( t \) and ending in \( u \) is also a period starting with a lower value of \( m \text{ at } t \) and ending in a higher one \( m \text{ at } u \).

Extending the notation, a process oscillating within some window of variation might be represented as \( t < u \rightarrow x \text{ at } t \equiv x \text{ at } u \). The equivalence relation \( \equiv \) allows \( x \) as a function of time to take values within some range of variation. Although the values may change, they \textit{stay in the same range} (a state). Depending on the resolution, (the equivalence class over which quotient is taken) the oscillating process appears as a series of changes or as a constant state (Zucchi 1998:363): a change of state, or a state of change. The same perspective can be applied to nonmonotone growth by changing coordinates (e.g. by considering derivatives). This line of thought relativises event type classification to granularity.

There is a correlation between lexical aspect and resultativity (half-closed event type) versus grammatical aspect and totality (closed event type), pointed out in Johanson (1998) This correlation seems related to the distinction between state of change and comparative change. There is a topological theorem saying that the set of points where a continuous function is constant (or two continuous functions coincide) is closed (Halmos 1974:78). This fits cycles like \textit{walk a while} which represent the coincidence of two states of change. The set of points where two functions differ is open, so the set of points where the improper equality \( t \leq u \) holds is half closed from right. This profile fits process achievements like \textit{grow up} which represents the half closure of an open comparative change \textit{grow} by a result adverb \textit{up}.

As suggested in the section on relation algebra, more and more can also be interpreted as relation composition more more. This construal takes care of the shifting \textit{tertium comparationis} in the concatenation of comparative changes implicitly. Comparison being a transitive relation, more equals the composition more more as well as the composition closure more' This was just the formal criterion of open event types. Overloading iteration in this way this gives a particularly simple representation for the event type \textit{grow} as more \( \cap \langle \), obeying the law

\[
\text{more} \cap \langle = (\text{more} \cap \langle)^+ = \text{more}^+ \cap \langle^+
\]

What concatenation in place of composition does is replace a free product with a fibred one, ensuring that a parameter is shared between successive members of the chain (van Benthem 1991,1996).
Comparative change can also be denoted by transduction. Consider the event type *come* or *become near I*. What happens topologically here that one enters ever smaller neighborhoods of as time passes. One step toward me can be formalised as the transducer (written left to right)

$$(x \text{ at } (y: I \text{ in } y) \text{ at } t):(x \text{ in } y \text{ at } u: t < u)$$

Composition of this event type with *You are at my house* you at $(x: \text{house}; I \text{ in } x \text{ now})$ with this event type yields the event type *You will be in my house now* $< y \text{ in } (x: \text{house}; I \text{ in } x) \text{ at } t$. The composition closure of this transducer is the event type *come to me*.

There is no need to choose between the above explications, or consider them competitors. They are just two aspects of the same elephant.

By manipulating the resolution of $t$, we can vary assumptions from monotone growth to overall growth while allowing for oscillations. Strict growth can be prioritised without ruling out stagnation by judicious use of priority versions of relevant operators.

**Additivity and growth**

The task of this section is to relate comparative change to sums. A basic sense of *more* is the partial order of inclusion obtained by adding *more* (another quantity of) water to have *more* (a larger amount of) water (Clark/Clark 1972). Comparative change or growth involves becoming *more and more*.

I start from the observation that pasts, or times from a *terminus post quem* up to later times, are ordered by inclusion. Such a past extends later than another iff it includes the other.

$$\text{if } t \leq u \text{ then } <t \leq <u \text{ iff } <t \subseteq <u$$

Injective mappings of events on such times are cumulative. If it rains every day, the rainfall accumulates with as time goes by. Then we may write monotone growth as:

$$\text{if } t \leq u \text{ then rain at } <t \subseteq \text{rain at } <u$$

This deduces accumulative growth from a sequence of similar events. By an analogous argument, we can deduce that the amount of rainfall is additive with respect to time, i.e. continuous with respect to Boolean addition. First note that successive times add up by disjoint union. In other words, concatenation of times is a special case of disjoint join.

$$\text{if } t.u \text{ then } t.u = t+u.$$  

Assuming that rain is injective (different rain falls on different days), we can deduce

$$\text{rain at } t+u = \text{rain at } t+\text{rain at } u.$$  

We may now study which event types are additive, subadditive, superadditive, or not additive at all (Krantz et al. 1971). Model theory tells which formulas are preserved with different model closure conditions. Positive formulas are preserved under joins and meets, existential under extensions and universal ones under submodels. Dualities arise here again. For instance, the number of people born and dead grows with time, while the number of people who stay alive decreases as the time gets longer.

When $t,u$ are measures (equivalence classes of events of the same duration) like *hour*, concatenation and disjoint join come to just the same thing, i.e. *hour+hour* is the same class as *hour.hour*. This allows equating the additive measure phrase $2\text{hour} = \text{hour+hour}$ with the concatenation $\text{hour}^2 = \text{hour.hour}$. This equation is the origin of extensive measurement of time. Measurement involves sums, which is why *for* entails openness. For instance, *work for an hour* is equivalent to *work for sixty minutes* which is the iteration of *work for a minute* sixty times over.

Using methods of measurement theory, it is possible to extend event multiplication or exponentiation from integers to fractions and reals. For instance, if *hour = 60 min*, the inverse is also meaningful: *minute = 1/60 h*. Fractional or real time iterates of events have a calculus of their own, called timed regular expressions or timed automata (Asarin et al. 1997).

The duality of events and time shows up here: the concatenation $e.e = e^2$ takes the time $t+t = 2t$.

**Object-event mappings**

The well known cross-domain referential analogies described in this section (Gruber 1965, Talmy 1986, Bach 1986, Langacker 1987, Jackendoff 1990) have been attacked formally by a number of writers (Verkuyl 1985,1987,1989,1993, Krifka 1989,1990,1992,1998 Jackendoff 1993, Pustejovsky 1991, Tenny 1994). The common insight is that a *countability* distinction, cutting across the Aristotelean categories of substance, time, space, and quality governs aspect composition. The preceding sections have indicated how it can be captured with the tools of Boolean and regular algebras used in this book. Again, my main point is intertranslatability between alternative conceptualisations. For
instance, using positional definitions of thematic roles, we can translate between (de)compositional and neo-Davidsonian event representations. This also means that neither representation holds special privilege.

The dependence of aspect on cross-domain mappings between objects, qualities and events has been studied in detail by Verkuyl (1993) and Krifka (1990), among others. The basic rule is very simple: bare noncount (plural or mass) noun phrases can produce open event types, all others produce closed ones.

The possibility of predicting aspect properties of events from referential properties of objects is another application of homeomorphy, invariance under continuous one-to-one mappings, which preserve bounds. Conversely, predictions may fail when the object to event mapping is not homeomorphic (but, say, one-way continuous homomorphisms, constant mappings etc., Krifka 1998, Zucchi 1998).

An event type \( e \) that is homeomorphic relative to one of its nominal arguments \( x \) satisfies the following laws (Krifka 1998):

\[
\begin{align*}
e(x) \cup e(y) &= e(x \cup y) & \text{(monotonicity)} \\
\bigcup e(x) &= e \left( \bigcup x \right) & \text{(continuity)}
\end{align*}
\]

The continuity condition graphically indicates that bounds are preserved by a homeomorphic event type \( e \): any maximal (bounded) event of type \( e(x) \) is \( e \) applied to a maximal (bounded) object of type \( x \). Weaker conditions are obtained by dropping one-one, onto, monotonicity or continuity assumptions in one or both directions.

Aspect inferences stand and fall on the strength of such mappings. For instance, Heinämäki (1974:15) suggests that total object accomplishment cannot be iterative if the object is singular definite, e.g. Vappu solved the problem (cf. problems) for two hours. But the accomplishment can be iterated if the mapping from events to objects is not one to one: Vappu solved the same problem for two hours is possible (Zucchi 1998:366).

As Verkuyl (1993) points out, there are many supplementary readings: The mailman was attacked by a dog for a week can be iterative or generic, conative (tried to attack), even an implicit quote (for a week, the story was that...)

In a great many cases, the modus operandi is vague and accordingly the event type is not lexically fixed. The best way to spell out a sense is using a more vague paraphrase. For instance, read a book allows both for an hour and in an hour if the event-object mapping is many-one onto. E.g. John read an ad is more likely to mean read once than John read the Bible. Structural explanations why a given reading satisfies a given mapping can then be derived from diathesis (quod vide). For instance, read once satisfies the homeomorphism conditions but read in general does not (Krifka 1998:213).

In Finnish, the partitive-nominative/accusative case distinction is used in the nominal domain (mass and plural) to make definiteness distinctions (Krifka 1992). It is also used in the temporal domain to express closeness distinctions. Consider the definiteness distinction first.

Tässä on vettä. ‘Here is (some) water.’ water \( \bigcap \) here

Tässä on vesi. ‘Here is the water.’ (water) \( \bigcup \) here

These sentences come out in our analysis in the expected way. Plurals are no different:

Tässä on miehiä. ‘Here are (some) men.’ pl man \( \bigcap \) here

Tässä ovat miehet. ‘Here are (all) the men.’ the pl man \( \bigcup \) here

Definiteness implies uniqueness, which is guaranteed by our definition: the unit (maximal element) of a Boolean algebra is unique.

It is well known (e.g. Verkuyl 1972, Heinämäki 1974, Carlson 1981) that certain verbs are closed if and only if an appropriate nominal argument in them is (non)count:

Vettä tulee sisään. ‘(Some) water is coming in.’ water \( \neg \) in.water in

Miehiä tulee sisään. ‘(Some) men are coming in.’ water \( \neg \) in.man in

Mies tulee sisään. ‘A man is coming in’. man \( \neg \) in.man in

This can now be proved from the fact that water is closed under joins, i.e. that water1 \( \bigcup \) water2 \( \subseteq \) water.

water1 \( \neg \) in.water in \( \bigcup \) water2 \( \neg \) in.water in

The same proof goes through with men replacing water, for the join of men and more men are again men:

men1 \( \neg \) in.men1 in.men2 \( \neg \) in.men2 in \( \subseteq \) men \( \neg \) in.men in

But the proof fails with singular man: man \( \bigcup \) man is not included in man (but in men).

Recall that we described the imperfective (progressive/iterative) aspect as a noncount (mass/plural) operator in the domain of events. It obviously has the requisite structure. Conversely, the perfective aspect is a count operator. Many cases of the Finnish object case aspect alternation can be compositionally derived in this way. For instance,
Reading is a monotone increasing function of the text read: to read a text, one reads its parts. This means that reading all of a part of a book equals partial reading of the complete book: Extending of to the partitive operation in the nominal domain (in would give better English!)

\[
\text{pf read of book} = \text{prog read } \cup \text{book}
\]

Russian can separate the two meanings (Tommola 1986:76):

On vypil vody/On pil vodu ‘He drank up some (of the) water/he was drinking (the) water’

Dahl (1985:75) notes that the perfective on napisal pis’ma translates into a definite article ‘He wrote up the letters’. Bulgarian Az izpix kafe ‘I drank up (aor pf) coffee’ is starred in Guentcheva (1990); the English translation is odd too. Finnish Join loppuun kahvia ‘I drank up coffee (ptv)’ is marginal.

Cases where this equation holds are a locus of neutralisation between partitive in the event domain and partitive in the object domain. Not all cases satisfy this equation. There are genuinely aspectual uses of the Finnish partitive object, where the partitive does not apply to the denotation of the object but directly on the denotation of the verb. Borderline cases include Mies auttoi naista/naisen autoon "The man was helping/helped the woman into the car’. Clearly aspectual examples, where there is a difference in resultativity which is not (in any obvious way) explained by a part rather than the whole of the object being affected, are ampuu ‘shoot/shoot at’ or etsiä ‘look for/look up’.

Mies ampui lehmää/lehmän ‘The man shot at the cow (ptv) /shoot the cow (acc) dead’.
Mies etsi puhelinnumero(n/a) luettelosta. ‘The man was looking for (ptv) /looked up (acc) a/the phone number in a/the catalogue.’

\text{Dead} is the default effect of shooting. An explicit or implied result adverb can change that.

\textbf{Aspectual roles}

Tenny (1994) is a survey of lexical diathesis types according to the ability of their complements to change aspect, in the tradition of transformational grammar. \textit{Measuring out} means that there is a monotone continuous mapping between causes, effects and causation events.

\[
\text{Uc cause } \text{Ue} = \text{U(}c \text{ cause } e\text{)}
\]

The causation event can be divided into an increasing nest of smaller ones so that any sum of effects is caused by a corresponding sum of causes. It is not difficult to test that the measuring out formula is trivially true when $c$ and $e$ are states or changes. It becomes more informative when $c$ and $e$ have nontrivial order structure

Tenny distinguishes three basic cases of measuring out: arguments, paths, and qualities. If we map her examples on a cause-become schema with predicate-argument conversion on the object, the three cases turn out to be very similar:

\begin{align*}
\text{Mary ate an apple.} & \quad \text{Mary cause apple become eaten} \\
\text{Mary walked the trail.} & \quad \text{Mary cause trail become walked} \\
\text{The gardener ripened the apple.} & \quad \text{Gardener cause apple become ripe}
\end{align*}

In these causatives, the aspect of the causation event reflects the topological properties of the effected change. The properties of the change in turn reflect topological properties of the subject of the change, if suitable cross-domain mappings exist between events, objects, and qualities:

\begin{align*}
\text{(eat apple) more } \leftrightarrow & \leftrightarrow \text{ apple (more eaten) } \leftrightarrow \text{ (more apple) eaten} \\
\text{(walk trail) more } \leftrightarrow & \leftrightarrow \text{ trail (more walked) } \leftrightarrow \text{ (more trail) walked}
\end{align*}

For the qualitative change ripen, a part-to-quality mapping from (apple (more ripe)) to ((more apple) ripe) may or may not exist (Tenny 1994).

Or we can capitalise on the path analogy and pick apart the course of events as a chain of subevents. The prediction that the event type is closed requires the assumption that the path is maximal in the event type. Paths are by default open (they can be combined and continued), which explains why \textit{Mary walked the trail} is a process accomplishment (Krifka 1992, Tenny 1994:fn 128).

201 The best one can say is that the imperfective is intentional: the shot was aimed at the cow, the search was after the number. Compare discussion of partitiva tantum below.

Mary ate an apple. \hspace{1cm} \text{Mary took first bite<Mary took another bite<Mary took last bite}
Mary walked the trail. Mary took first step < Mary took more steps < Mary took last step
The gardener ripened the apple. Apple is not ripe < apple is riper < apple is ripe

Tenny (1994) maintains that measuring out is germane to internal arguments. The distinction between external and internal arguments corresponds more or less to the two argument positions of cause. The privilege is encoded in a specific measuring out constraint for direct internal arguments, as opposed to subject and oblique (Tenny 1994:11):

Measuring-out constraint on direct internal arguments

(i) The direct internal argument of a simple verb is constrained so that it undergoes no necessary internal motion or change, unless it is motion or change which 'measures out the event' over time (where 'measuring out' entails that the direct argument plays a particular role in delimiting the event).
(ii) Direct internal arguments are the only overt arguments which can 'measure out the event'.
(iii) There can be no more than one measuring-out for any event described by a verb.

I doubt this. Subjects too can measure out events and determine aspect when they change. Intransitive clauses are not a bone of contention:

People die.
Smoke gets in your eyes.

Transitives are more interesting. Tenny's own example The documents proved John's guilt in fact is a rather good case of a subject measuring out a change in the object. Assuming guilty/not guilty is a two-valued quality, the progress of the proof is best measured by the accumulation of the documents. Tenny's point is that this does not affect aspect. Why? The reason is that because c cause e entails c ≤ e, the causation event c cause e is open or half-closed as soon as the effect e is. The only way c can decide aspect of c cause e is that e is closed and c maps one-to-one onto e. Examples:

People kill one another all the time.
Rain spoils the picnic all the time.

Replacing people with a closed subject, e.g. the same people produces odd results 202. Other arguments can also decide aspect on similar mapping assumptions. 203

Christ brings salvation to sinners forever.
Robin earned a dollar or two from tourists all summer.
We came up with new evidence all the time.
The expedition passed through uncharted territory for days on end.

What prevents measuring out transitive events by the subject is that an absolute change in the object implies no (absolute) change in the subject. The result causative like break entails no change on snow below. Conversely, manner causative push leave the change on the object underspecified, which prevents measuring out the event by the object.

The snow was breaking the skylight.
Mike pushed the button.

The uniqueness constraint in (iii) seems implied by the fact that topological closure is idempotent (Kelley 1955:43): once an event is closed, it stays closed. In sum, my impression is that Tenny's constraints are at best epiphenomenal.

Tenny distinguishes a set of aspecual roles mapped on syntactic arguments separately from and alongside thematic roles: measure, path and terminus. Duplication can be avoided if aspects are defined from diathesis and cross-category mappings. To the extent they hold, Tenny's linking constraints then ought to fall out as corollaries.

Here are some examples of Tenny's linkings related to diathesis and cross-category mappings.

<table>
<thead>
<tr>
<th>verb</th>
<th>aspecual roles</th>
<th>diathesis</th>
<th>role mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>pound</td>
<td>location</td>
<td>pf+ pound</td>
<td>object constant</td>
</tr>
<tr>
<td>eat</td>
<td>measure</td>
<td>eat cause x become eaten</td>
<td>object decreasing</td>
</tr>
<tr>
<td>play</td>
<td>path, terminus</td>
<td>x cause y play cause z sound</td>
<td>instrument constant, object non-increasing</td>
</tr>
</tbody>
</table>

202 Except if the same is taken generically meaning the same kind of.

203 Some of Tenny's (1994:88) evidence is flawed in that it involves count arguments. When the arguments are made noncount, the awkwardness subsides:

The ?hammer/hail broke the window quickly, a lot of it breaking the window at once.
**Internal objects**

Traditional grammar called *internal* or *effected objects* those objects which come about or vanish as the result of the event. This type of object can be explicaded in terms of measuring out.

Many languages associate the grammar of measure phrases to that of transitive objects. Why this should be so will become apparent here. The analogy can be appreciated from the iterate-and-test logic of accomplishments: *sing a song* means *sing while a song lasts* or until a song is over *sing(¬song)* or *(¬song).sing.(song ¬song)* and *sing a while* means *sing(while) sing while a while lasts or until a while is over *(¬while).sing.(while ¬while)*.

A prime case of measuring out are object like measure adverbs (distance, time, etc.) as in *run a mile* or *sleep eight hours*. This has the structure of a transitive event: running *covers or makes a distance*, sleeping *uses up, does away with, or takes*, some time. This indicates how to construe object like measure adverbs as an instance of the causative schema.

The construction can be motivated by going over a number of metaphors about gaining distance or spending time: Time goes to something. When an hour goes by, it is first entirely unused, in the future. After an hour, it is entirely gone. Whatever happens in between takes an hour. The hour exists at the point before the hour. It is gone is true at the point after it. Meanwhile, it is part there and part gone. So the event *an hour goes by* is *¬hour.hour.¬hour*, which is equivalent to just *hour*.

Now the natural suggestion is that *run a mile* or *sleep an hour* is an instance of the cause schema

\[
\text{run cause mile go by} = \text{run cause mile.} \\
\text{sleep cause hour go by} = \text{sleep cause hour.}
\]

Whether the mile or hour is *gained or lost* depends on perspective: whether one wants to make distance (from here) or lose distance (to elsewhere); or whether one means get some sleep, or lose some time.

But this is not the entire story yet. For one thing, the hour will be there anyway, so in what sense does sleep *cause* it to come or go? Second, it may not be usual that a cause is simultaneous with the effect. In fact no overlap is required between cause and effect (though full overlap is allowed). I need something more to prove that in this case it is. Since we don't get it from *cause*, it must come from the relation of events to time. In what sense does an event *take* time? They can only do it by happening at it, just like objects take space by being in it.

Consider the event type of *take* in general. A prototype event of taking is this: first something is somewhere else. Then it is with me, I have it. When an event takes time from me, first I have it, then the event has it. An event has the time when it happens on it, occupies it, takes it up. This is an instance of the symmetric possessive inversion:

\[
\text{e have t = t be at e} = \text{e be at t}
\]

An event takes that time when it happens at it. A person has time when he can choose what to do with it. Agents too are dual to events in this sense. An agent stands at the crossroads of past and future. He has time and events, but in opposite directions: his past full of events and his future as unused time to fill with events. The "time as container" metaphor (Lakoff/Johnson 1983) is an instance of the duality of time and events (Pratt 1992b).

So is the metaphor of time going fast or slow depending on how much happens in it. When nothing happens, time seems to drag on or stop completely. When a lot happens, time flies. This is absolute time (clock events) being measured by relative time (subjective events), rather than vice versa. When little happens, an event takes a long relative time. When a lot happens, each event takes a short relative time.

Getting back to linguistics, the frame for taking time is something like

\[
\text{e cause t go from x to e}
\]

which further unpacks through the go schema and possessive inversion to

\[
\text{e cause become e at t}
\]

The reflexive causation frame gets cancelled out, which leaves only the desired entailment *e at t*.

A closed or atomary event can *take* time, while an open event *lasts* some time. Taking is a change - a closed event. Lasting is a state - an open event. What has been taken cannot be taken, it is not there any longer.

To *spend* time is to cause time to go to something. To *use* time is to make time (together with something else) do something. If events take time, then they need time. They don't come about without time. Time allows events to come about, just as events cause time to go away. All of these locutions make literal sense, given the right morphisms.
It remains to explain why only open event types qualify for the object causative frame. This is where measuring out: the property that object like time adverbial is a durative adverb, comes in. As shown in dynamic logic, a causation frame can also be written using a causal until:

\[
\text{repeat } p \text{ until } c \\
\text{repeat } p \text{ until } \neg t
\]

Dynamic logic does not require that the loop repeat p is proper. It allows cycling p just once for c to ensue. My analysis of measuring out requires it, otherwise the concatenation in until between the bounded and bounding event will not be tight. This means that the repeat p loop is nontrivial, i.e. entails pp'. Conversely, the latter requirement entails the former. It is also tantamount with the requirement that p forms a proper cover of t, discussed in the connection with measure adverbials like for.

Compare, for contrast, jump two feet with jump two seconds where jump is a closed event type. The latter denotes a proper iteration of jumps. Or throw a ball a hundred yards / five seconds. (These are verbs of sending or launching: Nikanne 1990).

Examining jump and throw more closely, they have the structure of an initial closed impulse followed by an in principle open flight. In sublunar conditions, the flight is likely to end somewhere, so the entire event forms a cycle. However, that is not in the logic nor physics of the event type per se. It is also possible to jump off and throw things away. The impulse, in contrast, is a simple cycle: it is closed and arbitrarily short (relative to the flight). The distance measure applies to the flight, not the impulse. Jump two feet means fly two feet by a jump. In contrast, an internal object of time measures the cause rather than the effect. One cannot jump for any length of time without jumping more than once. A for adverbial can measure either. One can be shooting an arrow or be sending a message for a while, but also shoot or send it away for a while (until it returns). I return to jumps and throws in the section on dynamics.

The measuring out account of process causation also captures the intuition that object like measure adverbials and measuring out objects alike can act as bounds. The event goes on until, and ends when, the object has been dealt with, or when the time is up.

The event-time duality of measuring out events with time shows in a plethora of consumption metaphors associated with measure adverbs. Here are some for time: sleep away eight hours; lose, waste, kill time; spend, save, buy time; free time, spare time; use time for something; do something with one’s time. The metaphors of time as an instrument, vehicle or commodity are refinements of the time as container metaphor of Lakoff/Johnson (1983).

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204 The causal until schema former also allows the change c to happen later if c is gone is replaced with a future necessity modal c is foregone.
Part II. Case studies

In this part, the language independent developments of Part I are applied to problems of the TMA systems of a number of better known languages, as well as to thumbnail sketches of ones lesser known (to me).

English

The two most characteristic elements of the English TMA system are the perfect and the progressive aspect, standing in contrast to the simple forms of a verb. Smith (1991:106, cf. Curme 1931:373) boldly asserts that English simple aspect is perfective: “the English perfective viewpoint is often called simple aspect because it is signalled by the simple form of the main verb; the imperfective is signalled by with the auxiliary be+ing. The perfective is incompatible with an assertion that the event continued.” This claim gives best fit for English bare activity verbs in the simple past. Smith notes that *Lily swam in the pond and she may still be swimming there* is odd; so here *swam* means *took a swim*. On the other hand, the claim is hard to reconcile with the use of simple aspect with states, including generic event types. There is no implication of closure in the infinitive either: *I like to swim in the pond* equals *I like swimming in the pond*.

Smith’s solution leads to a diluted universal definition of the perfective to make room for English: “perfective presents in its entirety the temporal schema associated with each situation type” (Smith 1991:220). This sounds more like unmarked (neutral) aspect (Johanson 1998:§7.4, §10.2.2). The fact that the interpretation of simple aspect varies with lexical aspect in English suggests that English simple/progressive aspect contrast is better analysed true to surface as a privative opposition: English has marked imperfective aspect, while the unmarked simple aspect implicates closure where there is a live contrast with the marked progressive. Smith’s solution also requires a noncompositional treatment of the simple present where the present tense in effect nullifies the perfective aspect (1991:240).

English simple present

The English present tense of simple aspect matches the aspect of the event with that of (the current) now (Langacker 1982:288ff, Palmer 1987:4.2.2). There is not just one unique present reference time, any more than there are past ones; rather, now varies continuously in size as well as position (Jespersen 1968:258). This is all a matter of perspective: yesterday’s now’s are today’s then’s. Aspectually, the time of utterance (“as I am speaking”) is an open interval of no minimum duration, so if an event is to match it, it must be a state (Hirtle 1975:95, G.Carlson 1977a:424-432).

However, the exact time of speaking holds no particular place of pride among other present times around it. *I see it now* or *They are fighting* describes the current scene, while *He drops the ball* or *There it goes* are blow-by-blow accounts, not timing events to the time of speaking but moving the time of speaking further as the events go by (Langacker 1982, Lindstedt 1985:148). To relate an event in progress to an independently fixed time of utterance, the progressive is used: *Hush! I am watching TV*.

This line of thought fits well the fact that simple tense appear when the reference event can be chosen freely, as in stage instructions, performatives and rules (Palmer 1987:§4.2.2). Cooper (1986) goes further to argue that the simple present describes events that happen here and now (the location of the event is the discourse location).

    Here Bill enters the room.
    I move that we adjourn.
    See how they run. (Beatles)
    For six days out of seven the sun shines from a clear blue sky. On the seventh day it rains, all day. (Weldon)

Palmer’s (1987:§4.2.2.) observation that simple tenses are used when the topic is the manner or cause of an event, not its temporal location or duration, is apposite here. Example from Fay Weldon (*The Rules of Life*):

    She weeps here. The tape shivers. The voice falters. We are at the moment of trauma. … And here indeed the tape crackles again. Again the tears, then the pause and a gasp. Miss Sumpter weeps, steadies, speaks again. But she is not, when it comes to it, lamenting the frivolity of her life. “Why I weep now”, says Miss Sumpter, “is because I did not weep at the time.”

Note the progressive in the parenthetical sentence: it is not an event on the tape, but a commentary on what is going on on the tape. The comment is located in the relative time of the tape by the bit it comments.

Simple tenses cannot replace the progressive in English activities. This must be because English activities have a progressive, i.e. the marked aspect narrows the range of the unmarked form. Simple present isolates pushed aside by newer progressive forms are common (Bybee et al. 1994:231,276). If English simple aspect is what Dahl (1998) calls a residual gram, no positive characterization of the aspect type of the simple aspect is needed (nor is one easy to give) It follows that simple tenses of activities in opposition to progressives denote cycles unless coerced to generic habits or dispositions. In the simple past, an activity can carry on a narrative which confirms it is treated as a cycle.

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205For confirmation, note that progressive infinitive *I like to be swimming in the pond* is not the unmarked form as yet.
Honor, wisely, did not pursue the matter. We rested and talked about the dowry we would give our granddaughter to take with her to Scotland.

When Marilyn came in, the boys whistled. Everyone watched her walk around the room.

Joos (1967:135) claims the English present is a nonpast tense: ‘English grammar has no device whatever for cutting future time away from the time of speaking.’ Yet the English present is clearly less of a future tense than the Finnish or German presents, for future will narrows English simple present to scheduled future events.

Joos (1967:138) notes that the English simple present is unmarked both as an aspect and as a tense: the progressive cannot have non-temporary meaning, but the simple aspect can have it. At the same time, the simple past cannot have (actual) present meaning, but the unmarked present tense allows past meaning in historical present.

**English simple past**

I would give an English simple past sentence like ‘It happened’ the representation $e[\text{then}\,\text{now}]$

The English simple past is thus a definite (deictic, anaphoric or otherwise unique) proper past (McCawley 1971, Partee 1973, Tichy 1977) It is aspectually neutral. Definiteness records Jespersen’s (1924:271) observation that

> “Germans (North Germans?) will often say: Waren sie in Berlin? where an Englishman would have to say “Have you been in Berlin? When an Englishman hears a German ask “Were you in Berlin?” his natural inclination is to retort “When?”.

McCawley (1971:107) also notes that Did you see the Monet exhibition? talks about a definite past opportunity of seeing the exhibition. On the other hand, English simple past contrasts with for instance Finnish simple past in that English operates with descriptive criteria of identity (Hintikka 19??). The English simple past has no anaphoric implications when the event it applies is descriptively unique. Simple past in fact has to be used in English when reference is made to a unique past event.

Somebody apparently was here yesterday./Somebody has been through my things while I was away. He was born in 1952/He has been born again. Mona Lisa was painted by Leonardo./Many famous paintings have been painted by Italians.

Finnish uses present perfect here. simple past would sound anaphoric. This difference also reflects the fact that the English perfect is an extended now perfect while the Finnish perfect is an existential perfect.

Vlach (1993) too notes that the simple past is the tense to use of unique events in English, for instance

> Who gave (?has given) you that tie?

Mario Pei designed that building.

American English uses simple past more widely than British. McCoard (1978:241) quotes a list from Vanneck of the use of a “colloquial” simple past in American English where British English would prefer the perfect:

> He isn’t there now. I don’t know what happened to him.

Spain’s a nice country. I know some people who were there.

Hurray/Darn it! He did it again!

Yes, he’s here. I just saw him.

You missed him. He just went out.

Did you have lunch (yet, already)?

I didn’t pay for this book yet.

That show’s still on. I saw it twice.

I live in New York, but I never saw the St. Patrick’s parade.

Use of the simple past with quantifiers always/ever/never/once/twice and aspectual adverbials yet/already/still/again/just can be specifically singled out as Americanisms. As McCoard (1978:242), these are loci for neutralisation between the two tenses. Another area is the replacement of result perfect with a perfective past when the event is definite (indexical or descriptively unique): We brought you some flowers. I forgot my mantra.

Langacker (1982:277, cf. Smith 1991:106, Curme 1931:373) points out that the simple past of an English activity sentence like He swam denotes a cycle of swimming. There is a difference between He swam (and stopped) (unless swam is understood habitually) and He was tall (and still is). Unlike the progressive, the simple past of an English activity verb cannot denote an open, interior bit of swimming, but it denotes a cycle, a closed event.

As Langacker points out, a process accomplishment which has a temporal profile but is nevertheless open allows two interpretations, perfective or imperfective. (This is one reason for Langacker to classify activities together with
accomplishments as perfective processes.) If a language has a distinction between simple and progressive aspect, it can use it to express the distinction. This is what happens in English.

**English present perfect**

The English present perfect must be one of the most studied tense forms. All writers distinguish several readings or uses, reducible to one or more senses.

Four is a favorite number of uses (Matthews 1987). Thus Leech (1969:153) distinguishes the following four uses: duration of state up to the present moment, duration of habit up to the present moment, indefinite or recent past, and resultative perfective. McCawley (1971:104) also has four types: *universal* (I have known Max since 1960), *existential* (I have read Principia Mathematica five times), *stative* (I can’t come to your party tonight - I’ve caught the flu), and *hot news* (Malcolm X has just been assassinated). McCawley’s universal reading covers Leech’s first two readings, Leech’s indefinite past covers McCawley’s hot news and existential ones. Comrie (1976) also distinguishes four: persistent situation, recent past, experiential perfect, and perfect of result. Harris (1984) and Huddleston (1984:160-161) have extended now, hot news, indefinite anterior, and resultative perfects.

Schmole (1997,1998) and Zandwoort/van Ek (1975) reduce the number to three: continuative perfect, resultative perfect, and indefinite past. (leaving out hot news) Quirk et al. (1985:193) distinguish two cases of continuative perfect and one for the rest.

Early grammarians (Sweet 1900, Jespersen 1924,1933) as well as more practically oriented recent ones make do with a two-way distinction corresponding to the state-action distinction, incomplete perfect/inclusive present and complete perfect/permsasive present.


a) expresses a present state resulting from past action
b) expresses a past event which is unidentified as to time
c) expresses a past event within a time span which is continuous with the present, not differentiated into ‘then’ versus ‘now’
d) is made up of a past-tense embedded in a present tense

The first three approximate my result perfect, existential perfect, and universal perfect. The fourth theory is a syntactic analysis rather than a separate sense.

**Result perfect**

I join those who say the English present perfect is always the same, a near perfect e’r. The different senses come from the context, in particular, aspect type and adverbials. It is not really fair to ask which theory my definition is an instance of. If several senses fall out; it necessarily subsumes all of them. The result perfect is the near perfect of a closed event type where no further aspect intervenes, so in this sense it is prototypical. Dahl (1985) found the current relevance and hot news perfects (both result perfects in my book) to form the most prototypical core of his universal perfect concept. Slobin (1994) reports that result perfect is the first one to appear in English child language acquisition.

Result perfects from grammar sources:

Peter has injured his ancle and it’s still bad
Peter has injured his ancle but now it’s better (odd)
Has there been an accident? (Is this an accident scene?)
Have you seen my slippers? (Do you know where they are?)

Examples from Steinbeck:

He is inspecting it - no price has been mentioned yet. They have not come to a price.

---

206McCawley’s stative perfect is result perfect in my (and most other people's) terms, while stative perfect (quod vide) is not an aspect at all.

207Palmer (1987:§3.3.2) appears willing to subsume current relevance under extended now. Hirtle (1975:34) points out that bound present perfect may indicate future relevance in examples like When you have finished dinner, give me a ring.
“He will get well now”, he said. “I have won the fight.”
“You have heard of fool’s gold”, the dealer said. “This pearl is like fool’s gold.”.
The man behind the desk said, “I have put a value on this pearl. The owner does not think it fair. I will ask you to examine this thing and make an offer. Notice, he said to Kino, I have not mentioned what I have offered.”
Then coldness came over him as quickly as the rage had, and he said, “I am all right. The thing has gone.”
“We will, Father. And we will be married now. Kino has said so.” “Assim faremos, padre. E casaremos.
“This pearl has become my soul”, said Kino. “If I give it up I shall lose my soul.”
“They have taken the pearl. I have lost it. Now it is over”, he said. “The pearl is gone.”
“What will you do now that you have become a rich man?”
Let us throw it back into the sea. It has brought evil.

The hot news perfect a special case of a result perfect. McCawley (1971:107) observes that a recent death can be reported using a present perfect Dennis Brain has died in an auto accident. The implication is that the death is hot news. The hot news sense falls out when the circumstances are right for it. As Matthews (1987:123) points out, casting an event in the perfect does not yet make it hot news: it is news if it was not known to the addressee before, and it is hot if the event is recent (in fact immediate: it is the latest news about the matter at hand). How do we deduce has died is ‘hot news’? First, we saw that only (extended) present adverbials go with the perfect: Brain has died today vs. Brain died last year. Second, Brain has died in the past is an existential perfect die\textsubscript{r} now produced by the interplay of the past adverbial in the past and the perfect. The only way for die to be properly past is that its initial state has reappeared, which creates the odd implicature of resurrection on this reading. This only leaves over ‘hot news’ (near past result perfect with an implied now) for Brain has died.

Universal perfect
Universal (McCawley 1971) or continuous (McCoard 1978) perfect is the perfect of an open (and thus irresultative) event. The absence of a separate result follows from Aristotle’s principle that the result (end) of an open event is the event itself. The apparent universal quantification needs no special treatment in my calculus, for the default assumption is that open events match their event times.

Prototypical cases of universal perfect involve open (continuous or iterative) event types; durative adverbials serve as clues. The event is understood to continue up to now. It is left unsaid whether it still continues or will continue from now on. As Klein (1994:112) points out, the past up to now is closed by the present, so in that sense, universal perfect too is contextually closed.

Examples from McCoard (1978):
The money has lasted (two months).
He has sneezed for two days.
For the past several years our death rate has approached 40,000 per year here in the United States.
In recent years these dollars haven’t been as available to some of the countries as they would like to have it. But certainly and consistent with what I’ve said previously, that it’s our, that we’ll make an earnest effort to preserve the seat of Nationalist China.
The Secretary of State has not only reiterated the United States’ profound attachment to the alliance … [but] has also solemnly repeated a warning …
These are the questions that have taken me back, in the past few months, to a review of some of our decisions of national policy in these few years.

Existential perfect
There is a pervasive vagueness in English between extended now (“current/present relevance”) perfect and existential (“experiential”) perfect that has long occupied analysts. Although the perfect of an open event type like I have been waiting for you rather strongly suggests that the waiting has continued until now, even this implicature can always be cancelled. My solution is to place the ambiguity in the context. Similar solutions have been proposed earlier (e.g. Tichy 1977:358, Löbner 1988, Abusch/Rooth 1990, Vlach 1993).

The existential perfect was dubbed the perfect of experience in Zandvoort (1932). The name refers to cases where ‘the foregone event is felt to have added something to the experience of the subject and so exerts its influence in the aftermath.” I have read Oliver Twist “evokes the event as a part of the subject’s experience and so as something which cannot be taken away from him.” Similarly in My family has lived in this town, but not since 1638 (Diver 1963:147) “… the sentence evokes the event as a fact of the family history and as such inalienable from the family so long as it exists”.
“… The result phase is seen to persist at least in this attenuated respect: that once something has happened it can always be considered as part of the subject’s history and so as impinging on him at the moment of speaking.” (Hirtle 1975:74).
The name and characterisation is unduly narrow for the subject need not be animate. A neat example is
These forks have been ours, they have been my cousin’s, and now they belong to you.

Citing Wood (1957:68), “each successive ownership is represented as part of what we might call the history of the forks up to the present moment” (Hirtle 1975:75). The following are existential perfects in McCawley’s book:

My mother has changed my diaper many times.
Have you seen the Monet exhibition?

McCawley (1971:107) feels that the sentence about the diapers would not be said by a man who stopped wearing diapers 30 years ago. There is a feeling of recency to the existential perfect: some sort of relevance to the present is still involved. The extended now perfect suggests the habit of diaper changes extends to the present. The elusiveness of the current relevance restriction also falls out, for although an individual diaper change has a tangible result (new diaper), the iteration is irresultative (rather, the result is just that there have been many diaper changes.)

The Monet exhibition sentence suggests that the exhibition is still open (cf. Uldall 1948:149, Hirtle 1975:85). This can be reinforced with already/yet/before and canceled with ever. As McCoard (1978) sums it up, the “use of the present perfect reflects some reason for placing [the objects talked about] within a span of time conceptualised as extending right up to the present, as a past continuous with the present.” Note too that the negation I have not seen the Monet exhibition (yet) is a universal perfect true up to now.

None of the adverbials mentioned is able to guarantee that the exhibition is still open. There is a fine difference between yet/before and already/before, already/before allow more readily that I saw the exhibition at an earlier time when it was open (too): I am not coming, I have seen it before. It is not difficult to derive this difference from the definitions of the adverbials.

Examples of the existential-universal contrast from McCoard 1978:

I have lived here.
I have lived here on an off for ten years.
I have lived here for ten years by now/before.
I have lived here since then.
I have lived here every winter since then.
I have lived here whenever I am on vacation/can afford it

When have you ever been satisfied?

I have lived here exemplifies the observation that a bare activity sentence in simple aspect in English preferably assumes a closed reading. The reading of the sentence out of context depends on what context first comes to mind. With emphasis on lived, it could fit the topic: what have I done here? With stress on here, it could answer where have I lived? Both entail a closed cycle reading. Conversely, if I still lived here, why not just say I live here? It is more informative and entails the existential perfect.

Compare the state It’s been hot (Mittwoch 1988, Abusch and Rooth 1990). This is a typical conversation opener inviting agreement, only marginally more demanding than the present It’s hot. To obtain an existential reading, a more informative contrast is needed: It’s been hot before, it’s been hotter.

**Past adverbials with perfect**

A consequence of subsuming the existential perfect under near perfect in English is that though it entails a past event, the perfect still denotes an extended now. It goes with near past adverbials lately, since, so far etc and shuns proper past adverbials (Jespersen 1924:270, Poutsma 1926:260, Bryan 1936:379.;Joos 1967:145, Bennett 1974:62fn, Woisetschlaeger 196:85, Smith 1978, Chung/Timberlake 1985, Binnick 1991:271, Fryd 1998). Thus there is a pairing of present perfect I haven’t seen him so far/hitherto/up to now/since Monday/since last week/since I met you/lately against simple past I saw him yesterday (evening)/a week ago/earlier this week/last Monday/the other day/at four o’clock/in the morning/on Tuesday. Some adverbials cover both past and present and go with both forms: today/this month/this year/recently.

This constraint is one source for the feeling that even in its existential uses, the English perfect still has “current relevance”. As a near past contrasting with simple past, the perfect does not refer to or denote a contextually unique past event but is indefinite, only entailing the existence of one or more past occurrences of an event type.

The exceptionless part of the constraint against English present perfect with past adverbials concerns adverbials denoting definite proper past times. McCawley (1978:135) groups adverbials into those that go with simple past, perfect, or either. The following is based on his table. For corpus based studies, cf. Crystal (1966) or Matthews (1987).
at t<now> before at present
in t<now> during the past t as yet
last t in the past by now
the other day just now before now
those days once for the past t
yesterday recently herewith
since lately
on Tuesday since
in January so far
t ago until now

Table 61
Adverbials that only go with the perfect are tight near pasts. Adverbials that only go with the simple past are remote/proper past indexical/definite/specific ones. The ones that go with both are loose near pasts or not specifically past at all.

Mittwoch (1988:247) notes that an indefinite adverbial is possible when it is not indexically past: I have seen her on a wet Monday in January. Mittwoch (1988:216) puts it by saying that a past adverbial that goes with the perfect must be non-specific or include now. This is a semantic rather than lexical constraint: I have had breakfast at eight this morning is worse than either adverb alone or in other company (at eight before would do). Neither adverbial is markedly past alone, but the combined adverbial refers to a specific proper past. Conversely, McCoard (1974:135) points out that I’ve tried to reach them last night and this morning is fine, as last night and this morning combine to an extended now. Similarly, on Tuesday (an adverbial of the ‘either’ group) is fine as a partial answer to a question about near past 208

How has he been occupying himself this week?
Well, he has played golf on Tuesday. That’s all I know about so far.

Point time adverbials too are better in a list: This week I have opened the window at six and closed it at seven. Miller (1994:113) has examples where a generic context makes a proper past time adverbial unspecific (non-deictic):

It’s not much fun to arrive at the station at midday and find that the only train has gone at ten in the morning.
Next I pour on the sauce - which I’ve made the day before - (in a television cookery programme).


Twice already he has visited Japan, (namely) in 1898 and 1900.
We have received information on F.S. from you on the 22nd of September last.
We have seen other such situations since, and some of them not so long ago.

Sometimes the adverbial can be construed as an extended now rather than proper past.

I have forgiven her long ago.
I have made the same remark when I was younger (in my time).
It was one of those epidemic frenzies which have fallen upon great cities in former ages (in the past).

208 Cf Lindstedt 1985:86. Dahl 1985:138 notes that Swedish Jag har besökt England i januari 1942 is possible when the date is new information. Here too, the sentence forms a (possibly partial) answer to the universal (list) question When (= at what times) have you visited England (until now)? This example goes back to Diver (1963:157) who claimed that on Tuesday here cannot mean on a specific Tuesday (but means on a Tuesday/on Tuesdays).
The adverbial type \textit{t ago} is a notorious borderline case. Hirtle (1975:\$3.3.3) shows it appears with both tenses. The ambiguity can be seen as a dual ambiguity between past and extended now readings analogous to recently/lately. When \textit{long ago} has past focus, it is a proper past adverbial denoting events that happened long ago, \textit{t long now}. The event type \textit{forgive long ago forgive[t long now} then agrees with the simple past tense; and the present perfect (\textit{forgive[t long now})\textit{r now} is empty. Alternatively, \textit{long ago} means long since, denoting a long extended now \textit{long now}. Long since is fine with the perfect (Comrie 1985). On this reading, \textit{long ago} is compatible with the present perfect \textit{forgive long[r now}. It means \textit{she has been long forgiven or she has been forgiven since long ago} (Poutsma 1921:30), formalised as \textit{forgive[sf long r now}. This gives a fair hearing to McCoard’s (1978) negative feelings about \textit{t ago} perfects while allowing many other writers’ positive ones. Mittwoch (1988:216) notes that \textit{not long ago} is fine with the present perfect, denoting a loose near past recently. Miller (1994:115-116) finds \textit{ago} common in near past perfects like \textit{It’s just been announced five minutes ago}. Fryd (1998) connects this with its perfect origin \textit{ago \textless a-gone}. In contrast, co-occurrence with present time adverbials does not prove that a tense is nonpast, for loose present time adverbials \textit{today, this week and lately} extend to the past of the time of utterance. This holds even for \textit{now}, which can loosely denote a time around the time of speaking: \textit{Oh, now I dropped it}. Present perfect does not guarantee that the event time lies within the extended now. \textit{Today John has done his homework}. (Mittwoch 1988:247) is vague about whether John did the work today: \textit{homework[t today now} vs. \textit{homework today} now}. To sum up, the exclusion of proper past adverbials supports an analysis of the English present perfect as a near perfect \textit{e r}, denoting an extended now (Abusch/Rooth 1990, Parsons 1990:230,313). Under this analysis, its existential perfect uses come about through aspect shifts in the argument event type. Everyone agrees \textit{He has left yesterday} is not English (Palmer 1987:\$3.3.3). Parsons (1990) also finds future perfect \textit{Agatha will have run yesterday} unacceptable. Temporal reference is at issue rather than truth: \textit{Yesterday will have been the rainiest day of the year}, where \textit{yesterday} is not adverbial, is better than \textit{Yesterday it will have rained the most this year}, where it is. The ban on proper past adverbials with perfect does not extend to infinitive perfect. A simple explanation is that \textit{yesterday} is a reference time adverbial which has to agree with the tense when there is one. (Parsons 1990:254). The problem remains that \textit{yesterday} seems able to constrain event time with infinitive perfect.

He may/must/can/should/might/could/would have left yesterday. 

It is impossible for him to have left yesterday. 

He will be shown to have left yesterday.

Temporal focus in these cases can be tested with \textit{when} questions. The future perfect question \textit{When will he have left?} expects a future answer, e.g. \textit{tomorrow}, not \textit{yesterday}. In contrast, the epistemic question \textit{When must he have left?} can be answered \textit{yesterday}, not \textit{tomorrow}, which suggests that the epistemic modal has no temporal denotation. An unanchored answer \textit{in the evening} is taken to refer to the past, which indicates that the modal perfect sentence actually denotes past time. Formally: \textit{He will have left one day earlier} is fine, with the analysis \textit{leave day then now}, while \textit{He will have left yesterday} is out, because \textit{yesterday then now} denotes nothing. \textit{He must have left yesterday} is again ok: \textit{must \rightarrow leave yesterday < now}. 

As it allows event time to be separated from reference time, the English perfect infinitive is an existential perfect. Elsewhere, I argue that English pluperfect is a past existential perfect. The bottom line is that English present perfect is not the composition of tense and nonfinite perfect (unlike pluperfect). In English \textit{yesterday cannot attach to a present resultative} either (\textit{Those cakes are/were baked yesterday}). Perfect participle (\textit{Those cakes are the ones baked yesterday}) is possible. A ban on past adverbials with just finite present perfect is not unprecedented; near perfects in other languages obey it (Spanish, Portuguese) or have obeyed it (French, Icelandic\textit{bäinn}). The plausible reason why the finite indicative present perfect alone has remained a near perfect in English is its opposition to the other two finite past tenses on the one hand and the modals on the other hand. The finite present perfect divides semantic focus with the simple past and pluperfect, while the perfect infinitive covers all three tenses. Similar observations pertain to Portuguese compositional perfect (Johanson 1998:§8.4).

\textbf{Summing up}

On closer analysis, many examples could as well be classed elsewhere. This is just fine from my point of view; I don’t insist on distinguishing separate senses. The following passage will serve again as an example:

\footnote{McCoard 1976 quoting Stock observes that \textit{lately} also goes with the present tense: \textit{Lately, he makes his bed every day}.}
The publication in book form of the ephemeral triflings of a writer who prefers to conceal his identity, has drawn attention once more to a most regrettable state of affairs. The cheap gibes and vulgar music-hall jokes of this comedian have for long been a source of annoyance to all who have at heart the dignity of Letters. He has called in question, in a most downright manner, the genius of such men as Ibsen and Strindberg. He has assailed with the vilest abuse such unassailable names as Mr. Joad and Mr. Aldous Huxley. He has laughed loudly and rudely at Mr. Galsworthy and Sir James Barrie. Nothing, apparently, except his religion, is sacred to him. (McCoard 1978:55)

McCoard considers has drawn a result perfect, have for long been a continuous perfect, and the rest describe a series of actions, ‘presumably experiential’ (i.e. existential). But classification is rather shaky, and we can be relieved, inessential, as it does not belong to the perfect itself but its context, lexical aspect type, and adverbials.

The dependence of the occasional meaning of the perfect on lexical aspect is summed up nicely in McCoard (1978:147) following Dillon. Simplifying a little,

- When a clause is durative, the interpretation is “continuing until now:
  The money has lasted (two months).
- When a clause is momentary, interpretation is usually “iterative” (happening repeatedly before now):
  He has sneezed for two days.
- When a clause is completive, interpretation is resultative:
  The lake has frozen for two months.

Here for applies to the result of the perfect to measure the length of the result state. These readings are the likeliest ones because they require the least inference (interpolation). However, many examples are inextricably vague, as McCoard (1978:149ff) points out.

Different “senses” of the present perfect come out formally as follows.

He has been in London all the time. (i.e. he is probably in London now).

- be in London (state) = London
- have been in London = Londońr

He has come to London now. (i.e. He is probably in London now.)

- come to London (change) = ←London.London
- have come to London = ←London.London

He has been to London now. (i.e. He is probably not in London now.)

- have been to London = ←London.London.←London

He has been to London before. (he may or may not be in London now.)

- be in London before (event) = London<
- have been in London before = London<́r

Given aspect shifts, nothing about the present can be deduced from the perfect for certain. He has been in London at least once or Have you ever been in London? which have the form of an iteration of a cycle (pf London), unpack to an arbitrary number of visits to London and say nothing about where he is now. The existential perfect always seems to lurk around the corner undoing the effects of the result perfect, which is why “result perfect” dilutes to the rather lame “current relevance” perfect. The existential perfect is that special case of result perfect where the aspect type is disjunctive or existential, for instance, a cycle or iteration of an event. This is a nice result because it helps predict on what conditions the existential reading comes up.

**Alternative theory**

Abusch and Rooth (1990) propose a theory which explains the existential-universal ambiguity in terms of temporal anaphora. Translating their proposal to my formalism, the two readings are represented as

<table>
<thead>
<tr>
<th>Abusch/Rooth 1990</th>
<th>Alternative formalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betsy has been in Boston for two weeks.</td>
<td>Boston∩2weeks in x.now</td>
</tr>
<tr>
<td>For two weeks now Betsy has</td>
<td>Boston∩2weeks&lt; now</td>
</tr>
</tbody>
</table>
been in Boston. \((x\text{now}) \land x\in [2\text{weeks}]\)

Table 62

Abusch and Rooth’s first formula says that there is a span of two weeks in Boston within an extended now \(x\text{now}\). The contribution of \textit{now} in the second formula is to add that the two weeks coincide with the extended now. Abusch and Rooth construe this addition as an instance of tense anaphora: \textit{now} identifies the time of the durative adverbial \(2\text{weeks}\) with the reference time \(x\) of the perfect as shown by the extra conjunct. A preposed position also favors binding the adverbial to the reference time.

Abusch and Rooth's translations and mine are equivalent. The main difference is that Abusch and Rooth take the weaker existential perfect reading as basic, to which the near perfect reading adds an identity. In my representation, the stronger reading, the near perfect, is simpler, the weaker reading involves a dual (perfective or iterative) aspect shift. \textit{Now} obliterates the difference by marking the first time the sentence is true: As in \textit{Now I have it, now} by its contrastive position (Carlson 1983) implicates that before now I had not got it: Similarly, \textit{when will you be in Boston?} asks for the \textit{first} moment it is true, because that is the strongest true answer to the question. Contrastive \textit{now} makes the two readings fall together by the principle \(\forall (e) = e\).

It may not matter much for the synchronic interpretation of English present perfect which reading is basic (or for that matter, whether there is one). Typologically, a development from a near perfect to existential perfect is well attested, and English is obviously moving somewhere along that cline.

The influence of adverbial position on preferred reading has caused much discussion. It is well established that the perfect is composed of two operators (the present tense and the perfect aspect) each with their own complement of temporal parameters (Ejerhed-Braroe 1974,1982, Hornstein 1977, Heny 1982, Zagona 1988, Mittwoch 1988). A standard observation (Dowty 1979, Richards 1982, Mittwoch 1988, Vlach 1993:262) is that the placement of the adverbial influences the choice of interpretation:

Betsy has been in Boston for three months (before). For three months (now), Betsy has been in Boston.

The preposed adverbial favors the universal reading over the existential reading. Richards (1982) explained the contrast as a scope difference of \textit{for} binding either event time or reference time. His proposal was criticised by Heny (1982), Mittwoch (1988) and Abusch/Rooth (1990). Bennett/Partee (1972), Dowty (1979), Mittwoch (1988) and Abusch/Rooth (1990) all agree that in the universal reading, \textit{for} covers an extended now. Dowty 1979:343ff ends up making the perfect syntactically ambiguous between existential and extended now senses. As we saw, Abusch and Rooth (1990) treat this as a case of referential ambiguity.

When the \textit{for} adverbial is subjoined to the main verb, a surface true way of picking apart the sentece is \((\text{Boston}[3\text{months}] \land r \land \text{now})\) which says that there is a past period of three months spent in Boston. In contrast, if the \textit{for} adverbial is at front, an iconic analysis is \((3\text{months now} \land \text{Boston}) r \land \text{now}\) which says that there is a near past of three months in Boston. Here \textit{3months} is bounded by the present. These preferences are defeasible both ways (Abusch and Rooth 1990). The unmarked word order variant allows both readings. A list context like \textit{For three months, Betsy has been in Boston, in Providence and at Amherst} makes room for the existential reading, by giving the preposed word order another discourse function. (Vlach’s explanation of the preference is essentially the same; given that his chunking operator is a perfective aspect operator.) Dowty (1979:348, cf Abusch 1988:246) reports a similar scope preference for \textit{Since 1971, John has been in Chicago}.

Further evidence comes from the following variants:

\begin{align*}
\text{Today, Betsy has been in Boston for two weeks.} & \quad \text{today} \land (\text{Boston} \land (2\text{weeks})) \land r \land \text{now} \\
\text{For two weeks, Betsy has been in Boston today.} & \quad 2\text{weeks} \land \text{today} \land (\text{Boston} \land r) \land \text{now}
\end{align*}

The latter sentence is odd, and it is assigned an inconsistent translation. It can be saved by a marked enough topic, such as \textit{When has Betsy been in Boston for two weeks?} which in effect inverts the adverbials of the previous sentence.

Mittwoch (1988:220ff) asks how many readings a sentence like

\begin{align*}
\text{John has not slept for 12 hours.}
\end{align*}

can have. She ends up with six possible scopings of negation, tense, and \textit{for}, which produce five readings. It is always possible to divide up cases into five or more. How many \textit{one has} to distinguish depends on one’s semantics. In my view, there are just two scopings which make reasonable sense, corresponding to alternative case assignments in English as well as Finnish.

\begin{align*}
\text{perf 12h not} & \quad \neg \text{sleep} \land (12\text{h'}) & \text{John has not slept in 12 hours.} \\
\text{sleep} & \quad \text{tuntiin (ill)}
\end{align*}
The only scope difference here is whether negation has wide or narrow scope. Further "readings" are obtained by considering whether the 12 hours come in a row or are summed up of parts, and whether events abut to the present or are placed further in the past. But these are aspectual differences, not scope differences between not, have and for.

**Perfect vs. simple past**

Dahl (1985:188) suggests that the distribution of the English perfect is included in that of the simple past. This is not quite true. Only the perfect is able to denote an extended now, so the simple past cannot replace the perfect in the following.

I have been sick lately.
Now I have been here for a month.
He has been unconscious since the accident.

Jespersen (1949:§5.4) has collected a nice set of examples contrasting the simple past and the perfect. They show how the schematic differences between the two tenses can be used to implicate different contrasts in different contexts.

When I have been in London, I have seen him pretty often (several stays up to now).
When I was in London, I saw him pretty often. (one or more stays, now over)

Why does the subclause perfect entail several stays in the past here? First, English when (quod vide) must denote a time distinct from now. (While or now that would allow an ongoing stay in London.) Second, have been must denote an extended now. If the subclause denoted a unique past stay, its meet with an extended now would be empty. The obvious way to reconcile these requirements is iteration: pf London extends to now.

The Lord gave, and the Lord hath taken away.
Many of the hearts that throbbed so gaily then, have ceased to beat.
My beautiful! I think that God made you, and has given you to me.

In these examples, the event of the first clause is past, the results of the second clause current. The course of events give.take.now entails give\then<now\ and take r\now.

Death has come to him. Death came to him in an ugly shape.
The Professor has been to see me. Came in, glorious at about twelve o’clock.
…you will kindly tell me what has happened, when it happened, how it happened, and what Dr. H. has to do with it.

Here the first sentence summarises an individual event detailed in the following clauses. come r\now A come\then<now.

I have heard from him regularly for the last six months. I have often wished to tell you; but I was afraid you might misunderstand me, and —my courage failed me.

Has he said anything yet? - No she has not. And yet there have been times when the poor girl has wanted to speak, and yet could not quite bring herself to take the plunge. I have tried to help her, but I dare say I did it clumsily, and scared her off from it. She has spoken about my old family, and our reputation, and I always felt it was leading to the point; but somehow it turned off before we got there.

Same thing, only the summary denotes a habitual course of events whose instances are detailed. As concerns event time, the perfect is indefinite and does not form narratives, while the past is definite and can. Recall McCoard’s example cited several times above:

The publication in book form of the ephemeral triflings of a writer who prefers to conceal his identity, has drawn attention once more to a more regrettable state of affairs. The cheap gibes and vulgar music-hall jokes of this comedian have for long been a source of annoyance to all who have at heart the dignity of Letters. He has called in question, in a most downright manner, the genius of such men as Ibsen and Strindberg. He has assailed with the vilest abuse such unassailable names as Mr. Joad and Mr. Aldous Huxley. He has laughed loudly and rudely at Mr. Galsworthy and Sir James Barrie. Nothing, apparently, except his religion, is sacred to him. (McCoard 1978:55)

The sequence of perfects has called in question, has assailed, and has laughed below just form three independent arguments that the author being chastised has for long been a source of annoyance and that nothing is sacred to him. As McCoard (1978:55) notes, it is impossible to tell from the passage whether any of these indiscretions was committed
more than once. It is also impossible to tell in what sequence (if any) they happened. Indefiniteness about event time supports the use of the perfect as an evidential tense where the event is inferred from its effects:

I have been looking through my papers tonight. Some have been converted to kitchen usees, some the child has destroyed. This form of censorship pleases me for it has the indifference of the natural world to the constructions of art. (Durrell, Hirtle 1975:88)

Thielke (1958, Hirtle 1975:89) quotes an insightful explanation of the evidential-witnessed contrast in a crime novel:

I have no doubt that Bolton is an experienced and able officer; and experience is a very good thing, but it sometimes leads to a rather excessive self-confidence. It was a small mistake he made, but a significant one. “My God! So I killed her!” That was what the witness understood me to say, and that was what he wrote down. What I did say, as my lord told you, was “My God! So I’ve killed her!” I do not believe, members of the jury, that you will fall into the error of thinking that the difference is a trifling one, and of small account. It is a very significant difference indeed. If you, any of you, had murdered a woman, you might exclaim in a moment of agitation: “I killed her!” You would certainly not say: “I have killed her”. A foreigner might say that, being unfamiliar with ordinary English idiom, but no Englishman would. On the other hand, if one of you gentlemen on the jury were conscious of having caused a great deal of mental pain and distress to your wife, and you were suddenly informed of your wife’s death, what more natural than that you should imagine, in your remorse, that she had been driven by your conduct to take her own life? And what more natural than that you should exclaim “My God! So I’ve killed her!”

Another court case:

They were very staggering words to me. I recall them quite plainly. -To whom were they addressed? Not to you police officers? (Dryly) I should not think so for a moment. They were addressed to Miss Lawrence, and if she has not heard them it was because she was turned away from him. (Bedford, quoted by Joos 1967:144, Hirtle 1975:89)

Joos called this use of the perfect ornamental. I agree with Hirtle (1975) that this is evidential use of perfect. Reportedly, Miss Lawrence did not hear the words. If she did not hear them, she need not agree there was an occasion to hear them, as the simple past would suggest. Cf Hirtle: “thus it might be paraphrased ‘… and if she says she did not hear them …’ which amounts to ‘if she claims to have not heard them…’ There also may be a suggestion of the speaker not endorsing the testimony…” Compare

Did you hear you were fired? - I haven’t heard anything of the sort.

where the perfect not only denies hearing, but there having been any occasion for hearing up to now. Russian (quod vide) has similar presupposition-denyng uses of the imperfective aspect. Compare also Jespersen’s (1949:§5.4)

If I have erred, there was no joy in error. err<rfnow → err<then<now.  
Whence came this new conscience to me I know not, but come it has.  
The rain stopped about two minutes ago. - So it has.210

These too are cases of indefinite perfect vs. definite past. The perfect makes no reference to a particular occasion (the defendant, unlike the accuser, is not ready to admit such a presupposition); but supposing there was such a time, there was no joy then. In the second example, the first clause points out that the event is unspecific (though unique); the second clause stresses the existential claim.

English pluperfect

An English pluperfect is by school grammars the simple past of the perfect and the simple past of the simple past (Palmer 1987:§3.3.3., Mittwoch 1988:216). This refers to the fact that pluperfect can be the backshifted narrative of both simple past and present perfect:

It turns out he has lived in Paris for years. > It turned out he had lived in Paris for years. 
It turns out he left Paris last week. > It turned out he had left Paris the week before.

In the face of this, we cannot say that the English pluperfect is the simple past of the perfect, as the morphology suggests (Bennett/Partee 1972:5.5), i.e. that it is represented by perf esnow. Composing the definition of the near perfect and the simple past, the perfect in the past reading with reference time modification live rfthen<now comes

out as desired. The past of the past reading with event time modification \((\text{leave})\text{week then})\text{r} then<now\) is less satisfactory. The problem is that of \(he has left Paris last week\) shifted to the past.

We must look for the greatest common denominator of the simple past and the perfect. It is none else than the existential perfect \(e<\text{r}\), which is entailed by both simple past \(e<\text{r}\) and perfect \(e\text{r}\). We can thus define the English pluperfect as the simple past of an existential perfect:

\[e<\text{r} then<now\]

This form is entailed by the simple past of perfect \(e\text{r} then<now\) and entails the past of a simple past \(e then<now\). The perfect in the past is obtained by contracting \(<\text{r}\) into a point and the past in the past by providing \(e\) with a definite reference time \(\text{then2}\).

Smith (1991:243) maintains that in perfect sentences, time adverbs specify reference time, citing a pluperfect sentence with \(already\) as an example:

John had already watered the lawn yesterday.

In my view, this is not true for English pluperfect. Unlike present perfect, a pluperfect has two past times which a past time adverbial can match, the reference time of the finite tense and the event time of the perfect aspect (see chapter on sequence of tense).

In March, I had only read two of the books.
John had left the room when Mary had thrown the ashtray.

The first example is ambiguous between readings made explicit with \(by March\) against \(during March\). The second sentence is four ways ambiguous. It represents the simple past of any of the four sentences below (McCoard 1978:210, Declerck 1994:144).

\[
\begin{align*}
\text{John leaves the room when Mary throws the ashtray} & \quad \text{throw} leave \\
\text{John leaves the room when Mary has thrown the ashtray.} & \quad \text{throw} r\text{leave} \\
\text{John has left the room when Mary throws the ashtray} & \quad \text{throw} r\text{leave} r \\
\text{John has left the room when Mary has thrown the ashtray.} & \quad \text{throw} r\text{leave} r
\end{align*}
\]

Compare also the following example from Joos (1967) where pluperfect replaces the perfect because the people are no longer on their feet at the time they subside to their places:

The high-backed chair has been pulled, helped forward, the figure is seated, has bowed, and the hundred or so people who \(had gathered\) themselves at split notice to their feet rustle and subside into apportioned place (Joos 1967:139).

Bennett and Partee (1972:5.5) feel \(John had eaten the fish by today\) should be ruled out. In my formalisation: \(today\leq eat\text{r} then<now\) is consistent, but redundant because \(then<now\leq today\) is tautological. The redundancy can be removed by making the bounding adverbial a past one (\(by six today\)). It is not impossible to conceive a context for the sentence even as it stands. The remaining awkwardness is due to split perspective.

After eating the remains last night, John had eaten the fish by today, as he had promised.

**Pluperfect vs. simple past**

Hill (1958:214) claims that English pluperfect and the simple past are always interchangeable (at least without loss of well-formedness, if not meaning):

Curiously, there are no good examples of sentences in which either the \(had\) phrase or the simple past is required, and all situations in which one is possible one can employ the other.

Diver (1963:150fn) challenges Hill’s claim by suggesting that the following pluperfect is indispensable:

He approached the bridge with some caution, not entirely convinced of its safety, even though the engineers \(had tested\) it thoroughly only two days before.

The reasoning behind Diver’s claim can be guessed. The concessive clause \(even though\) depends on the past propositional attitude \(not convinced\). The fact reported in can affect the attitude subject only if he was aware of it, so the concessive clause must be in the scope of the past propositional attitude. Consequently, the tense of the concessive clause must depend on that of the attitude. Its event time must be anterior to its reference time because it must match the anchored anterior time adverbial \(two days before\). Anterior to a past tense, the tense can only be the pluperfect. Diver can maintain that one still “can employ” the simple past, if only at the expense of losing perspective. Similar contrasts between between a direct discourse simple past and narrative pluperfect occur in discourse (Caenepeel and Moens 1994).
Hirtle (1975:3.2.2) produces further examples of the same type:

As soon as the teacher entered the classroom he saw that one of the boys had drawn a sketch of him on the blackboard.

They disqualified him because he was/had been absent.

Erades (1957:283, Hirtle 1975:§3.2.3) points out that the pluperfect is systematically used in English for reported fact comparable to quotative forms in many languages: “The difference is, briefly, this: the pluperfect represents the idea … from the point of view of ‘the reporter’; the preterit – the same tense, hence, as used in the direct statement – looks upon it from the standpoint of the original speaker.” For instance, in

We [the police] went to his home and asked to see the parcel. At first he refused to show it to us. Then we told him about the dragon. He knew nothing about it. He went straight to Mandwick, where he left Mrs. Robinson’s shop. Then he was afraid and opened the box. It contained - sleeping powders. While he was in hospital, he slept very badly. The doctor refused to give him any more powders, so he took them when the nurse wasn’t looking. He was very sorry about it, and he has gone back to the hospital with the powders.

“The pluperfect --- would have suggested that the detective was relating what the young man had told him, without necessarily vouching for the truth of this story. It would merely have represented what the young man said had happened. But the form in which the facts are given by the detective implies that is really what did happen: he accepts the man’s story.”

Does English have obligatory deictic shift as in French (quod vide)? There is an apparent consensus that deictic shift is not obligatory in English clauses subordinate to a past tense if the simple past has independent reference, i.e. if the subordinate events need not be related to the narrative time (Jespersen 1931:§22.5, Fludernik 1993:180). Fludernik (1993:181) offers a minimal pair:

When I visited Wallace in the hospital (he told me/I heard) he (was/had been) run down by a bus.

Fludernik finds simple past better with he told me, because it is the tense quoted directly from Wallace's eyewitness story of how he got hospitalised. Declerck (1997:100) appears to disagree, starring

I said I would go to John, who would be/*was back by then.

What we hoped was that we would receive aid from John, who would have/*had been informed by then.

The disagreement must be only apparent – the simple pasts are grammatical precisely when the tenses are free and the riders de re. Declerck is right in saying that the speaker cannot choose freely here, for the choices mean different. The starred readings are the back shifts of the (equally starred)

I think I will go to John, who will be/*is back by then.

What we hope is that we will receive aid from John, who will have/*has been informed by then.

A free simple past can appear where a bound pluperfect might as well (or better, Hirtle 1975:55). The tense is as it were 'transparent' to the layering of the narrative, pointing directly from one or the other of the two narrative situations to the event. Depending on which, it can be taken as an intrusion of the narrator or as a quote from the character.

It wasn’t as cold as it was the day before. (Salinger)

It made me sicker than I was. (Spillane)

If I knew you would look like that I’d have asked you out myself. (Spillane)

A number of boys who only last summer were playing on their court were now in the trenches and many would never play again.

Dean was actually pretty good at appearing competent, but he theorized that he was being punished for something he said to somebody. (Scott Adams: The Dilbert Principle:245).

From a locked drawer she took out a large German revolver. Basil had given it to her – it was a souvenir of the war that he had acquired at secondhand. It was loaded when he had brought it to her and was loaded now. (Declerck 1997:167)

With simple while clauses, simple past is definitely preferred (Huddleston 1969:793, Declerck 1994:92): The clause could be contracted to a participle while waiting.

I heard that John had been reading the newspaper while he was/?had been waiting.

Bache (1985) provides the following case:

By then, Alex and Sally had been lovers for ever. love\negages\rfun\rin\rthen\r\lthen\r\lnow

The formalisation shows that simple past is consistent with by then only if the deadline then is matched by the event it bounds. This is possible if the bounded event is a state:
By then, Alex and Sally were lovers. love \{ages\} \{then \leq \} then <now
Replacing the pluperfect with simple past gives
By then, Alex and Sally were lovers for ever. love \{ages\} \{then \leq \} then <now
There is a tendency to read for ever as a plan or result adverb here to get it out of the bounds of then.

**English progressive**

Jespersen (1949:\$12.5.2) describes the English progressive thus:

If we say he was (on) hunting, we mean that the hunting (which may be completed now) had begun, but was not completed at the time mentioned or implied in the sentence, and this element of incompleteness (at that time) is very important if we want to understand the expanded tenses, even if it is not equally manifest in all cases.

Mittwoch (1988:251) represents the view that the English progressive merges two previous constructions, predicative be Ving with a present participle and locative a be on \{a-\} Ving with a gerund. She suggests that the former is a source for an open progressive and the latter for a momentaneous one. The former was common in Middle English before the merger took place (Jespersen 1931:191).

Jespersen (1949) and Poutsma (1921) have looked for minimal pairs contrasting the English progressive with the simple tenses. The simple tenses are generic describing events happening “permanently or customarily, not necessarily actually”, or describe “events without any notion of duration implied” (Poutsma 1921:50).

Rousseau knows he’s talking nonsense. A man who talks nonsense so well must know that he is talking nonsense. (Johnson)
A great awe seemed to have fallen upon her, and she was behaving as she behaved at church.
I was crying all the time, but, except that I was conscious of being cold and dejected, I am sure I never thought why I cried.
He said, moreover, what he felt, instead of echoing what every one else was feeling.
Do you go through the park? - Not usually. But I’m going to-day.
Did he say this to everybody, or was he saying it to her specially?
It was freezing as it only freezes in March.

The examples indicate that the two forms are in privative opposition (Joos 1968:112), with the progressive the marked member. The key thing is to keep a close count on the precise events the different forms denote; the times referred to turn out to be correspondingly different. The contrast between the next two examples is instructive: the progressive tells what is happening meanwhile; the simple tense redescribes one and the same event.

Lush spoke carelessly, but he was really seizing an opportunity and fixing an observant look on Grandcourt.
Did you come on your cycle? No, I walked.

**Progressive stative**

The English interior progressive indicates that a process is involved (Bybee et al. 1994:126): “Progressive views action as ongoing at reference time. As Comrie (1976) defines progressive, and as we find it used in English, it applies typically to dynamic predicates and not to stative ones. Thus the progressive is typically used for actions that require a constant input of energy to be sustained, as in Sara is reading. States continue without further energy input unless something occurs to put an end to them. Thus Sara is knowing the answer is not normal English (Smith 1991:20, Gabbay and Moravcsik 1980:75). Poutsma (1921:II.2.339, Palmer (1924:149) and Jespersen (1949:\$14.6.5) produce lists of verbs shunning the progressive.

The progressive of a state, when acceptable, implies an associated process: He was being helpful ‘he tried to do something to help’ (Poutsma 1921:\$39-42, Marchand 1955, Lakoff 1970, Lee 1971, Smith 1983,1990:20). These cases are known as progressive statives (Dowty 1979:165, Smith 1991:79,84). Even understanding/remembering/knowing are acceptable when they can be paraphrased by be in the process of:

I’m understanding more about quantum mechanics as each day goes by. (Palmer 1987:\$4.6.1, Comrie 1976:36ff, Mourelatos 1981:196)
His mind was hard and suspicious and he was remembering the white powder (Steinbeck)
He was hating you all the time. (Poutsma 1921:90).
John is knowing the answer more and more often this semester. (Smith 1983)

There is a comparative change or a thought process implied (Langacker 1987:256). Though he is knowing that S for a fixed S remains bad, Smith’s example implying iteration is already passable.. Cf. also section on temporary states. English progressive He was being helpful ‘He was acting helpful’, to Portuguese estava/foi agradavel ‘He was

**Progressive habitual**

Unlike many languages, the English progressive also applies to generic event types. *He is now sleeping on the floor* may mean not only that he is at this moment lying asleep on the floor, but also that he has made (or is obliged to make) it his practice to spend his nights on the floor for the time being (Poutsma 1921:51). This is a sign of grammaticalisation toward imperfective aspect.

Far from redundant in generics, the progressive disambiguates for iteration in many contexts:

> By the end of six months he was receiving/received a wage of fourteen shillings as salesman.
> My aunt is staying/stays with me. I’m sleeping on the floor in the drawing-room.

Another example is the following (Abusch and Rooth 1990):

> The value of Acme stock has increased.
> The value of Acme stock has increased for some time.
> The value of Acme stock has been increasing.

Abusch and Rooth (1990) note that *has increased* only entails a net rise, while *has increased for some time* seems too entail a relatively continuous rise. This is exactly what their (and my) analysis of *for* predicts, for it entails a series of points each of which shows a net rise relative to the previous one. (This still allows temporary plunges in between.) Now the progressive seems to imply the *for* sentence, which follows if the progressive picks out a relative rise between one on either side of it.

The opposite scoping, a generic of a progressive, is exemplified by Poutsma (1921) with

> The earth is a ball that is always turning around..
> Miss Bassey was generally visiting the poor, or, as was the case at this moment, asleep in her arm-chair..

Note however the explicit quantifiers *always* and *generally*. I have no examples of unmarked aspect shift from progressive to generic.

**Temporary progressive**

Compare the English simple and progressive pasts in *I read your paper* and *I was reading your paper*. The simple past sentence is complete and context free as it is. The progressive either suggests the reading was temporary and irresultative: *I was reading it a while, pf prog read* or that some particular event yesterday is being referred to which it provides background to: *I was reading it when you rang, prog read \(\cap pf \ ring\)*. The three sentences translate differently into Portuguese as *Li-o,* and *Estive a lê-o, Estava a lê-o quando ligaste*, respectively.

**Future progressive**

Poutsma (1921:62) observes that future progressive compared with simple future represents events as spontaneous or unplanned: The progressive leavetaking or hortation seem somehow friendlier, more casual than the simple tense; the progressive predictions are surmises, not promises.

> I’ll see/be seeing you tomorrow.
> Come away, the dinner will be getting cold.
> A week hence we shall be eating better grub than this.
> This peace will be turning all our rich naval officers ashore. They will all be wanting a home.

These impressions follow from the aspect distinction. The simple tenses announce a program of action, where the progressives make a predictions about goings on at future observation times. *I’ll see you tomorrow (at eight) fixes an appointment; I’ll be seeing you ( sometime) tomorrow is just a presumption.

A related observation is that the progressive disambiguates *may/must/will* for an epistemic reading as against a deontic reading with the simple tenses. The progressive observes what is happening, the simple tense dictates what is done (Poutsma 1921, Bertinetto 1998).

> I may do/be doing wrong.
> Somebody must go/be going away.
> O, she must always do/be doing something extraordinary.
Perfect progressive

The characteristics of perfect progressive fall out from the composition of perfect with progressive. Here is a list of them.

An implicature of iteration or continuation is inherited from the progressive. The contrast to a perfective reading of the simple perfect is clear in the following examples from Hirtle (1975:115):

- The baby has fallen/been falling out of bed.
- He has hit/been hitting his little brother. (Diver 1963:161).
- He has winked/been winking at me.
- I have received/been receiving news from him. (Sweet 1900)

The implicature of recency can be attributed to the finer time scale imparted by the progressive: a shorter bit in the past must be nearer in time to stay in perspective. Jespersen’s (1949:§13.2.1) minimal pair *He has collected/been collecting evidence against her* is illuminating. The simple form can equal *collect r* or *pf collect r*, the progressive form *prog collect r* or *pf prog collect r*. Though the simple form may be slightly more apt to be perfective than the progressive one, the main difference is the difference in time scale and provisionality due to the progressive.

A common implicature of the progressive is that the event continues up until or past the reference time (a near past):

- I looked at the nest I had been carrying (and was carrying still)
- It was another or rather fuller sort of companionship that poor Dorothea had been hungering for (and still was).
- He has been smoking (just now) ‘Il vient de fumer’.
- Well, we have perhaps been spoiling her a little. (Cf. We have spoilt her.) (Hirtle 1975:105).
- The baby has eaten/been eating his porridge. (Hirtle 1975:119).

As Hirtle points out, the evidence for the last example is different depending on aspect: an empty plate (perfective), or a sticky baby and dirty high chair (progressive).

Mittwoch (1988:237) in fact claims that the present perfect of a progressive is never experiential (existential). There certainly is a preference for a perfect progressive event to be understood as going on at present unless there is tangible evidence to the contrary. However, there cases where the event has obviously *stopped* (though not *finished*) before now:

- You have been drinking (again).
- I have been thinking about your suggestion.
- I can tell you two have been quarreling.

Here the progressive manages to suggest that there has been a bounded bit of an uncompleted process in the recent past, i.e. the aspect type is a cycle *pf prog*.

Perfect progressive undoes any implication of perfectivity of the simple perfect (Poutsma 1921:64ff, Hirtle 1975:§3.5.2). In *What have you been doing/done today?* the progressive form asks for activities, the simple form for accomplishments.

Hornby (1964:97) finds progressive much more probable than simple aspect in *I’ve waited/been waiting here for an hour*. In Cohen's (1989:231) translation, the difference is the one between *voici une heure que j’attends ici* vs. *j’ai attendu ici une heure*. It is theoretically and grammatically possible to say *These books have lain on the floor of your study all week, but have been lying* is much more probable. The progressive form replaces the implicature of completion of the perfect with one of unfinished business. Conversely, the following accomplishments could not easily be put in the progressive:

- Newton has explained the movements of the moon.
- Shakespeare has written the greatest tragedies the world has ever seen.

Jespersen (1949:§13.2.7) notes that many optionally transitive process accomplishments require object in the simple perfect (*he reads/*he has read a lot, I know/I have known it, he drinks/*you have drunk enough). The progressive perfect can be intransitive: *I am have been reading (all afternoon), you’ve been drinking, I am reading/eating/drinking equals I am reading/eating/drinking something*. The progressive picks out the process which causes the transitive event, which amounts to noncount (plural or mass) quantification over the object.

The perfect progressive of an activity, implying iteration, actually makes a stronger claim (the claim that the event has gone on for *a while*) than the simple perfect, which is true as soon as the activity has occurred *at all*. Compare *walk (at all) to be walking (around), I have walked is too weak to count for an accomplishment in most contexts, while I have been walking (taken a walk) is fine. Hatcher (1951:254, Hirtle 1975:121) actually stars the simple past in her examples *She has cried/played cards/fooled with my papers*. Hirtle (citing Allen 1966:203) notes that the simple perfect becomes acceptable in a context where the key is whether the event has been recorded *at all*.
She’s pouted. She’s sulked. She’s cried. She’s screamed. She’s tried everything that could be expected of a spoiled child.

The simple at all sense of the perfect is strong enough in Has the baby/patient walked yet/today? or I have lived, by God I have lived.

Hirtle (1975:101) too finds the simple perfect barely acceptable in the following type of sentence:

- He has written/been writing a book for two years.
- They have phoned/been phoning for two days.
- Someone has knocked/been knocking at my door for five minutes now.
- You’ve asked/been asking this question for three weeks now.

Jespersen (1949:$13.2.4) mentions a contrast noted by Palmer (1924) between He hasn’t been speaking since three o’clock (but only since half past three) and He hasn’t spoken since three o’clock (he’s been silent since three). This is a case of scope of negation: the corresponding positive He has been speaking since three is fine, while the perfective He has spoken since three is awkward.

**Used to**

English used to is a past habitual e^+now^+. The notation tells that the event type e^+ is open and extended, and so is now^+. The resolution is of this course of events is low: both the past event and the present are extended The event e extends until now^+ nowadays, which in turn extends to the past of now. I used to smoke yesterday sounds funny (Kucera 1981:184-185, Lindstedt 1985:127).

Used to thus strongly suggests a previous past, of the logical form a¬a.now denoting the latest event of type a before now. It is not very natural with a definite past time l...like I used to live in Chelsea last year unless a habit can fit inside the time frame. The event type e^+now^+ does not entail a¬a.now. It does implicate as much, as it makes two open event types border on one another. If they overlap why not say I am / have been living in Chelsea?

Used to can report a remote closed habit in the past hab e < now. This does not entail the habit is over; as usual, it is enough for a reference time to be over: He used to smoke a lot when I knew him and apparently he has kept the habit. Used to is paraphrased I had the habit of (remote past), not I have had the habit of (near past possibly going on to the present).

Jespersen noted the use of habitual near past used to in reference to a definite but unspecified open event in the past, corresponding to once on closed events (Kuhn 1989:518):

I used to live in Chelsea / I once lived in Chelsea / I once visited Chelsea.

Used to weakly suggests that Chelsea was the last place where I lived before now, contrasting Chelsea¬Chelsea.now with once ¬Chelsea.Chelsea ¬Chelsea.now. This latter explication correctly predicts the slight oddity of I once lived at home. On the other hand, the earth was once devoid of life does not seem too odd, at least no less than used to be. The near past used to seems slightly out of place with remote events.

**English passive**

Given that English past tense can be free or bound, we have four paraphrases (and translations) for was buried in the following text..

He knew the pearl would be buried in the house, and he thought Kino might look toward the place where the pearl was buried. ‘A pérola devia estar enterrada dentro de casa e pensava que Kino havia de denunciar com os olhos o lugar onde a escondera.’

- look ∩ then Abury ∩ then they were burying it then
- look ∩ then2 Abury ∩ then1 Athen1 < then2 they had buried it earlier
- look ∩ then A perf bury ∩ then they kept it buried then
- look ∩ then2 A perf bury ∩ then1 Athen1 < then2 they had kept it buried earlier

The Portuguese translation for could be imperfective, perfective or pluperfect, respectively. The actual translation has estar enterrada ‘be buried’ and onde a escondera ‘where he had hid it’. The English progressive was being buried or pluperfect had been buried would disambiguate for or against the first reading.
Portuguese

Portuguese is well known for a complex system of verb inflection. Part of the complexity is due to the coexistence of new analytic spoken language forms alongside older suffixal forms on the way to being relegated to written language.

Perfeito simples

The Portuguese past tenses have aspectual import. Perfeito and Imperfeito are perfective and imperfective simple pasts, respectively. Perfeito, like its Latin ancestor, does duty for both simple past and present perfect.²¹¹

Perfeito: pf e<now

I shall first look at the cases where Perfeito translates the English perfect. Although Perfeito does not guarantee that a result persists at present, it does not rule that out either. However, Portuguese Perfeito simples is a past tense. It contrasts with the Perfeito composto in

Este inverno tem chovido/choveu muito. 'This winter it has been raining/rained a lot'.

The composite perfect tem chovido suggests that it is still winter and rainy. The simple perfective choveu suggests that the rainy winter is over (Hundertmark 1982:§8.53). An English present perfect with now is translated by the Presente with Agora que, or else now is avoided. English perfects with lately/until now/so far are translated with the Perfeito Composto.

“What will you do now that you have become a rich man?” ‗Agora, que és (pres) um homem rico, que pensas fazer?‘

The weather has been fair until now. ‘O tempo tem estado (pc) bom.’ (cf. fr Il a fait beau jusqu‘ici.)

I wasn’t in when you came this morning. But now, at the first chance, I have come to see the baby. ‘Não estava em casa quando lá foram esta manhã; mas, logo que pude, vim ver o pequeno (lit. but, as soon as I could (pf), I came (pf) to see the boy)‘.

With a quantifying adverbial, Perfeito comes close to an English universal perfect. The adverbial rules out a closed past perfective reading of the basic event type which would by default take precedence. As in English, it does not guarantee that the event continues now.

Nunca foi a Itália. ‘He has never been (pf) to Italy.’

Sempre teve boas notas. ‘He has always had (pf) good grades.’

My family have been prominent, well-to-do people in this Middle Western city for three generations. ‘A minha família foi (pf), durante três gerações, gente próspera e importante nesta cidade do Middle west.’

I haven’t become one day or one hour older since I returned from Perelandra. ‘Não me tornei (pf) um dia ou uma hora mais velho desde que regressei de Perelandra.’

As a past tense, Perfeito does not denote an extended now. It cannot be used to imply that an open event type continues through the present. An extended now can in Portuguese denoted by present tense subjoined to the auxiliary há/havia t (que) ‘for t (in the past)’ or to the bounding adverbial/conjunction desde (que) e ‘from e on/since e’ Unlike há, desde is not specifically past, it also goes with desde agora ‘from now on’. The present used with these adverbials to denote an extended now is shifted to Imperfeito in past narratives.

Vivemos aqui há dez anos/Há dez anos que vivemos aqui. ‘We’ve lived (pres) here for ten years (lit. it has/there are ten years that we live here).

Desde que o João estive/está doente que não come bem. ‘Since he was/has been (pf/pres) ill John hasn’t been eating (pres) properly.’

Perfeito composto occurs too (shifted to Mais que perfeito in past narratives):

É verdade que essas loucuras se apoderaram de mim, que desde criança até hoje tenho sido todo delas. ‘It is true that these follies have possessed (pf) me, that I have been (pc) entirely in their power since childhood until today.’

²¹¹Latin perfect could act as a present or past tense for the purposes of consecutio temporum:

Etiamne venistis ut hic aut iuguletis aut condemnatis Sextum Rosciun? ‘Have you come (perf) here to kill or condemn (conj,pres) S.R.’?

Tandem impetravi abiret. ‘At last I got him (perf) to leave (conj,impf)’. 
With past tenses há t means ‘t ago’, i.e. it looks like a loose past location adverbial, not a tight durative one, i.e. we have another duality switch.

Ele estava aqui há um momento, disse Denniston. ‘He was (ipf) here a moment ago, Denniston said.’
Ele saiu há dois horas. ‘He left (pf) two hours ago.’

The present perfect reading is reinforced by presence of já ‘already’, because the present reference of já blocks a remote past interpretation:

Já foste ali? ‘Have you been (pf) there yet (lit. were you already there)?
Já viste a exposição? ‘Have you seen (pf) the exposition yet? (cf. Viste a exposição nessa altura? Did you see (pf) the exposition at the time?)

As the English paraphrases show, já asks whether the visit has taken place by now. By our discussion of already and by now, the event type is pf there≤now, i.e. the possible time of visit extends to the present by já. Cf. als

A acusão é homicídio. É um homicídio praticado há cinco anos e trata-se do assassínio do melhor amigo que alguém já teve. A longa espera 17

**Perfeito vs. imperfeito**

In a narrative, Perfeito acts as a closed past contrasted with the open Imperfeito. How does one decide when to use Perfeito and when Imperfeito? Markedness yields a simple rule of thumb: use Imperfeito for lexically open event types and Perfeito for lexically closed ones. Only when this rule does not work, an explanation is in order.

Thus in the unmarked case, open event types are in the Imperfeito, even if they are known to be to be over, as long as the bounds are not at issue (when they provide background to the goings on in the narrative rather than constitute a part of the goings on). Here, the wife has been murdered, and the husband corrects his tenses accordingly.

O senhor deixava-a muitas vezes sozinha. - Sim, sou obrigado a isso devido ao meu trabalho. Ela compreende.
Nós não gostamos - gostávamos -, mas é assim. Era.

‘You left (ipf) her alone often. Yes, I have to because of my job. She understands. We do not (pres)- did not (ipf) like it, but that’s how it is (pres) - was (ipf).

Eles já corromperam homens melhores do que você até agora. Straik era em tempos um homem bom, Filostrato era pelo menos um grande génio. Mesmo Alcasan … era pelo menos um simples assassino, alguma coisa melhor do que aquilo que fizeram dele até agora.

‘They have corrupted (pf) better men than you are. Straik was (ipf) once a good man, Filostrato was (ipf) in any case a great genius. Even Alcasan … was (ipf) a simple murderer, something better than what they have made (lit. made (pf) until now) of him.’

Mesmo os vulgares cientistas… como eu próprio era em tempos…começan a descobrir isto.

‘Even the normal scientists … as I was (ipf) myself once … are beginning to discover it.’

Perfeito on open event types implies some sort of a past episode which sets bounds to the state. This is perspectival use of the aspects: the imperfective tells how things were around some earlier time, without implying anything about how they were at other times, the perfective tells a bounded episode of the event type took place within a given time in the past (again whether or not it ended there). In the first example below, Denniston had seen Ransom and describes that event. He does not even agree yet that the Ransom has left (‘he was here only a moment ago’), In the second, the past presence of people is not described, but inferred from the tracks (‘they have been here’). Compare the evidential use of the perfect.

‘Bem, disse Dimble. Aqui não há ninguém. - Ele estava aqui há um momento, disse Denniston.’

“Well”, said Dimble, “there’s (pres) no one here.” “He was (ipf) here a moment ago,” said Denniston.

‘Olhem! - disse ele - aqui estiveram diversas pessoas. Não, não andem por cima dos rastos, que os confundem todos.’

“Look”, he said, “there have been (pf) several people here. Look. Can’t you see, sir?”

‘Ele estava com a director aqui. Depressa! Temos de passar uma busca à casa e ao jardim.’ Foi um género qualquer de impostor ou espião.

‘He had (ipf) the director here. Quick! We have to search the house and the garden. It was (pf) some kind of impostor or spy.’

Perfeito is possible when a state is manifested through action (compare progressive states in English):

O comandante foi um pouco grosseiro quando lhe expus a situação.

‘The commandant was (pf) a little crude (i.e. acted crudely) when I explained (pf) the situation to him.
Mas os cientistas _foram_ demasiado rápidos para ele.
‘But the scientists were (pf) too fast for him.’

A modality that entails an event takes its aspect from it:

Ransom _não_ _teve_ dificuldade em se aperceber…
Ransom had (pf) no difficulty noticing… (i.e. he noticed)

_Foi_ extremamente infeliz que eu tivesse chamado no preciso momento em que esperava a sua chegada.
‘It was (pf) extremely unlucky for me to have been called away at the very moment I was waiting for your arrival.’ (i.e. I was called away)

In clefts, the aspect of the support verb copies that of the main verb.

_Foi_ _nessa altura que essas florestas cresceram
‘It was (pf) at that time that the forests grew (pf).’

_Mas, quando se deitou_ para dormir, _não foi_ nas limitações humanas ou na sua própria ignorância que _pensou_.
‘But when he lay (pf) down, it was (pf) not human limitations or his own ignorance that he thought (pf) of.’

Passive auxiliary naturally does likewise:²¹²

_Mas quanto ao próprio Maleldil, tudo isso _mudou: foi mudado_ pelo que antecedeu em Belém._
‘But as for Maleldil himself, all that changed (pf); it was (pf) changed by what happened in Bethlehem.’

_Quando a refeição _chegou_ ao fim, Frost _conduziu-o_ à antecâmara da Cabeça e uma vez mais _foi_ despido e vestido com um macacão cirúrgico e uma máscara.
‘When the meal ended (pf), Frost took (pf) him to the antechamber of the Head, and once more he was (pf) undressed and dressed in a surgical overall and mask.’

_Nesse momento _foi_ interrompida. Um ruído de arranhar e de gemer tornara-se audível à porta.
‘At that moment he was (pf) interrupted. A scratching and whining noise had come (ppf) from the door.’

If an existential or predicative clause describes the occurrence of an event, the verb is perfective.

_O questionário que então lhe fizeram _foi_ totalmente diferente das perguntas dispersas e imaginativas dos hrossa._
‘The interrogation that they did (pf) to him was (pf) entirely different from the scattered and imaginative questions of the hrossa.

_Houve_ duas particularidades do nosso mundo que _pareceram_ interessá-los de forma especial. Uma delas _foi_ …
‘There were (pf) two peculiarities of our world which seemed to interest them especially. One of them was (pf) …

_E que instruções deu aos seus grupos? - Essa _foi_ outra dificuldade._
‘And what instructions did you give (pf) to your groups? - That was (pf) another difficulty.

_Aquilo _foi só o vento? - disse Grace Ironwood. - A mim _soou-me_ como um cavalo - disse a Sra Dimble._
‘Was (pf) that only the wind?’ said Grace Ironwood. “It sounded (pf) to me like a horse,” said Grace Ironwood.

_Nesse momento a sala toda _tremeu_ de ponta a ponta. - Que diabo _foi_ isto, disse Jane. - Se ainda houvesse guerra, teria dito que _foi_ uma bomba, disse Ivy._
‘At that moment the whole hall trembled from end to end. What the devil was (pf) that, said Jane. If it were still war, I would have said that it was (pf) a bomb, said Ivy.’

Continuation verbs are in Perfeito if they deny the occurrence of a change at a given point.

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²¹² Only active forms have suffixal tenses in Portuguese. Event passives are formed from _ser_ ‘be’ and the passive participle. There are state passives composed of passive participles with _estar_ as well.

_Hoje as florestas _estão_ petrificadas. ‘Today the forests are petrified’._

_Está_ tudo dito em S. Paulo. ‘It is all said in St. Paul.’

_O rosto _estava_ em extremo marcado pelo tempo… ‘The voice was marked by time in the extreme’._
O professor manteve-se perfeitamente imóvel e observava-o enquanto ele comia. ‘The professor remained (pf) perfectly still and observed (ipf) him while he ate (ipf).’

O mundo continuou a ignorar um dos mais graves perigos que alguma vez ameaçou a raça humana. ‘The world went on (pf) ignoring one of the gravest dangers that (had) ever threatened (pf) the human race.’

An interesting neutralisation in Portuguese is that the perfectives of the verbs ser (be) and ir (go) fall together. This is actually not surprising, for a bounded stay somewhere implies a visit there (be to London = go to London). This is also evident in my formulas for be and go, see the section on diathesis. As the third person plurals of the perfective and the pluperfect are the same, and the third person plural is also a polite address form, one form foram is eight times ambiguous (from a non-Portuguese point of view): They/you were/had been/went/had gone.

As mentioned earlier, Perfeito is the usual aspect of past universal sentences:

Sempre gostei de estar à janela olhando o céu, aceitando o silêncio que brota da noite profunda.

Nunca ele viu tanto bocado de dinheiro. (lit. he never saw that much money)’

That is a great deal of money, more than he has ever seen. ‘Já é um bom bocado de dinheiro.’

‘Sei que nunca gostou de mim - disse Mark. ‘Mas não sabia que era tanto como isto.’

“I know you’ve always disliked me”, said Mark. “But I didn’t know it was quite as bad as that.”

‘O falso ideal humanista do conhecimento como um fim em si mesmo nunca me entusiasmou. Sempre quis saber, a fim de obter utilidade.’

‘O falso ideal humanista do conhecimento como um fim em si mesmo nunca me entusiasmou. Sempre quis saber, a fim de obter utilidade.’

The false humanist ideal of knowledge as an end in itself never appealed (pf) to me. I always wanted (pf) to know in order to achieve utility.

‘Foi só ultimamente, Ransom, que fiquei a saber, por experiência vivida, algo em que você acreditou toda a sua vida, como parte da sua religião. … Agora sei que sou o maior cientista que o mundo jamais produziu. It is only lately, Ransom, that I’ve learned from actual experience something which you have believed (pf) all your life as part of your religion. … I know now that I am the greatest scientist the world has yet produced (pf).

Imperfeito

The Imperfeito is a past imperfective. It is the unmarked past of open event types and lends progressive, iterative and habitual meanings to closed event types. The demarcation between Imperfeito and the Progressivo will be discussed under the latter heading.

Imperfeito: ipf e<now

Here we must look at converse exceptions to the rule of thumb, where imperfective is applied to lexically closed event types.

Descriptions of habitual courses of events can have Imperfeito all through.

O director-adjunto raro dormia. Quando se lhe tornava absolutamente necessário fazê-lo, tomava um medicamento, mas a necessidade era rara. … As cores, sabores, cheiros e impressões tecteis sem dúvida bombardeavam-lhe os sentidos da forma normal: agora não lhe atingiam o íntimo. … Enquanto cérebro e lábios executavam o seu trabalho, … a parte mais íntima de si mesmo ficava livre para prosseguir a sua vida própria.

‘The Deputy Director rarely slept (ipf). When it became (ipf) absolutely necessary to do so, he took (ipf) a drug, but the necessity was (ipf) rare … Colours, tastes, smells and tactile impressions doubtless bombarded (ipf) his senses in the usual way: but they did not reach (ipf) him … While the brain and the lips did (ipf) their work … the innermost part of him remained (ipf) free to lead its own life.

No oitavo dia ele começou a falar em voz alta. - É justo, meu Deus! dizia ele repetidamente. … Depois voltava subitamente à questão da comida que eu não lhe davava. … Começou a levantar a voz - pedi-lhe que não o fizesse.

‘On the eighth day he began (pf) to talk aloud. ‘It is right, my God!, he said (ipf) repeatedly. … Then he suddenly returned (ipf) to the question of the food he did not give (ipf) him … He started (pf) raising his voice - he asked (pf) him not to do it.’
Imperfeito with *nunca/sempre* can describe an iteration (habit) in the past or redescribe a series of events. Imperfeito also appears with the durative *há T que* ‘for T’. *Sempre* means all the time or each time here; the context providing the occasions.

Ele *perdia todas as vezes* que jogávamos. ‘He kept losing (ipf) every time we played’.

‘O pessoal *nunca se demorava* por lá muito tempo - o meu pai *tinha sempre* aquela relutância em pagar os ordenados.’

The staff *never stayed* (ipf) - my father was (ipf) always reluctant to pay them wages.

‘Por que é que me *dediquei a Física*? Por que é que *descobri os raios Weston*? Por que é que *fui* para Malacandra? Ele… a força era quem me *impelia todo este tempo.*’

Why did I do (pf) physics? Why did I discover (pf) the Weston rays? Why did I go (pf) to Malacandra? It - the Force - *has been pushing* (ipf) me on *all the time.*

*Havia dois dias que não via* a sua senhora, que *não recebia* dela uma ordem, que *não adivinhava* um desejo seu para satisfazer imediatamente. ‘It was two days since he had not seen (ipf) his mistress, had not divined (ipf) a desire of hers to satisfy immediately.’ José de Alencar, *Guarani* Ch. VIII.

It remains to study if the Portuguese Imperfeito covers any other uses associated with imperfectives in other languages. The following example resembles the Russian (or Finnish) use of the imperfective to indicate an irresultative, reversible event (cycle):

‘Enquanto trabalhava, o médico disse: -- Foi uma felicidade eu conhecer o veneno do lacrau. Senão… E *encolhia* os ombros como quem nem sabe o que podia ter acontecido.

The doctor spoke a little as he worked: ‘It is lucky that I know about the poison of the scorpion, otherwise - ‘ and he shrugged (ipf) to show what could have happened.

Portuguese imperfective with a suitable past adverbial covers the use of perfect in examples like those below. Note the contrast with a closed perfect in the last example.

Contudo era isso, mas ou menos, o que eu *já esperava*. *A longa espera* 11.

Quando Lindsey julgou que eu *já me encontrava* de pé há tempo suficiente, declarou: - És um filho da mãe atrevido, Johnny. *Nunca* pensei que iria acontecer desta maneira. *A longa espera* 17.

*Tempos atrás*, Meyer *sorriria* (cond ipf), divertido, com todos estes cuidados, mas agora via as coisa por uma perpectiva diferente e já *adoptara* as mesmas precauções, embora a hipóteses de acontecer algo de nefasto àquele economista gadelhudo fossem muito pias reduzidas do que as minhas. *A mistério do iate desaparecido* 19.

**Perfeito composto**

Portuguese Perfeito composto is the near past of an open event type, thus it implies that the event continued until the present. (Again, it says nothing definite about whether it continues at the present time.) Morphologically it is a periphrastic form built like the English perfect from the perfect participle and a possessive auxiliary. The common auxiliary now is the current possessive auxiliary, *ter* (lat. *tenere* ‘hold’), but the old one *haver* (now an existential verb ‘there is’) is also found.

**PerlComp: a’r**

Perfeito Composto It accepts open events and coerces closed events into such (Oliveira/Lopes 1995, Santos 1996, Johanson 1998.§8.5.2.2). It has a present tense but falls together with the pluperfect in the past tense. Most examples involve states or habits in the near past. Examples:

‘Se isso é possível, quer dizer que *temos sido roubados toda a vida.*’

If that is so, then all of us have been cheated (pc) all of our lives.

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213Santos 1996 claims that the position of *sempre* before/after the verb correlates with the interpretation of *sempre*: *Ele sempre nadou no mar alto/ele nadou sempre no mar alto* ‘He has always swum in deep waters/he used to swim always in deep waters (then)’. This can be due to contrastivity. There is something of the same difference in Finnish between *Hän on aina käynyt meiliä/Hän on käynyt meiliä aina* ‘He has always come to see us (never missed us)/He has been visiting us forever (not just once or twice)’. In a contrastive position before the finite verb, *always* contrasts with *not always*, as new information after the verb, with all the other frequency adverbials. (This actually falls out from the analysis of information structure in Carlson 1983.)
‘Ele nunca nos deixou — disse Ransom — tem estado aqui em casa. — Queres tu dizer que ele tem estado à espera na sala do lado estas horas todas?’

He has never left (pf) us, said Ransom, he has been (pc) in the cottage all the time. You mean he has been waiting (pc) in the next room all these hours?

Onde tem estado? Tem alguma ideia do que tem estado a acontecer-lhe durante os últimos dias? Onde esteve vós estes últimos dias?

‘Where have you been (pc)? Have you got any idea what has been going on (pc) lately? Where were you (pf) for the last few days?’

‘Mas embora tenha havido poucas relações tem havido uma influência profunda. A influência deles na história humana tem sido de longe maior que a dos micróbios, embora, é evidente, igualmente não reconhecida.’

But though there has been little intercourse, there has been (pc) profound influence. Their effect on human history has been (pc) greater than that of the microbes, though equally unrecognised.

‘Todas essas coisas que tem estado a dizer são baboseiras.’

All of these things I have been saying (pc prog) are rubbish.’

Note the (near) interchangeability of the Perfeito composto and the Perfeito simpies in some examples.

Sometimes, especially with já, Perfeito Composto sentences can have an existential shade (there have been instances of something in the past, a series with nonnull frequency). This shade, I believe, comes from the event type rather than the tense. Again, with a suitable adverbial, the Perfeito Simples can say very similar things.

O rapaz já tem estado doente (várias vezes). ‘The boy has been sick (frequently) before.’

O rapaz já esteve doente (várias vezes). ‘The boy has already been sick (several times).’

Tem havido eldila que não acham isso uma alegria — disse Ransom.’

There have been eldila who didn’t find that amusing, said Ransom.’

Not yet quite the same, though, as Santos (1996:468) points out: the Perfeito Simples is still closed, while the Perfeito Composto is open; the former denotes a bounded number of times, the latter an open repetition. For analogous observations about Spanish present perfect, see Bertinetto/Delfitto (1998).

**Mas que perfeito**

Portuguese has two pluperfects, one suffixal (from Latin) and one which is morphologically the past of Perfeito Composto. The suffixal pluperfect only has active forms (as in Latin). The difference seems to be stylistic, the suffixal one getting confined to written language. 214 The composite pluperfect is not (only) a past tense of the Perfeito Composto, but it applies to all event types. (Compare English pluperfect.)

The suffixal pluperfect falls together with the Perfeito in third person plural. Often this does not make much of a difference, for Perfeito acts in Portuguese as a free tense anyway. There is little difference between English dependent pluperfect had escaped and Portuguese free perfective escapou (especially after first mention) in flashbacks like

It was in fact the frame of one of the very large family paintings which my fist suitor, the arsonist Walter James, had taken into his head to burn, hoping thus to avenge his wrongs. The frame had escaped the fire: it was the last thing my father managed to save before the fire consumed him too.

‘Era, aliás, a moldura de um dos enormes quadros da família que o meu primeiro pretendente, um incendiário de nome Walter James, tinha metido na ideia que havia de queimar, na esperança de que assim se ingariar das humilhações sofridas. A moldura escapou ao incêndio: foi a última coisa que o meu pai pôde salvar antes de o fogo o consumir também.’

The Perfeito escapou detaches the Portuguese narrative from the time frame of the flashback one step earlier than the original. In the final summarising sentence, both languages use a simple past (the summary is already outside the flashback).

**Progressivo and ser/estar**

The Portuguese progressive seems rather like the English one, except that competition with imperfeito constrains its use as a general imperfective. There is a differences as to which verbs allow it (rather, direct translations of verbs do not always have direct translations in the progressive):

Estou a ver/compreender (prog) ‘I see/understand, i.e. I am getting the point/I am following you’

214 In Spanish, suffixal pluperfect was first trapped into subordinate contexts (Bybee 1994:234).
I shall go into this difference later in connection with the *ser/estar* distinction. For now, I shall just say that it implies loosening of the constraint imposed on *p* in the formula for the progressive to a temporary state. Portuguese narratives use progressive much less than English (Santos 1996), obviously because *Imperfeito* provides an option. The progressive disambiguates between progressive and generic reading in *Estavas a sonhar/Sonhavas* ‘You were dreaming/dreamed’

E, como sempre quando acordava, ela *estava* a olhar-lololhava-lo. ‘And, as always when he woke up (ipf), she was looking/looked (prog/ipf) at him’.

E então Kino percebeu que eles *estavam* a comerriciumiam. ‘And then Kino understood (pf) that they were eating/ate (prog/ipf)’.

A Sra Dimble … *estava* a dormir com a cabeça em cima da mesa, uma peúga meja passajada ainda apertada nos joelhos. … A Sra Maggs dormia com a boca, bondosa e vulgar, toda aberta. ‘Mrs. Dimble was sleeping (prog) with her head on the table, with a half mended sock still pressed on her knees … Mrs. Maggs slept (ipf) with her generous and vulgar mouth full open.’

In the last example, the progressive and the imperfective are nearly interchangeable. The example bears a resemblance to an example from Sweet (1900) describing a tableau:

It is a representation of a lady. She is lying on a couch. At the side sits a woman in grief.

As Sweet noted, the lying posture of the first woman appeals more directly to the eye than the sitting posture of the second. In the Lewis novel too, Mrs. Dimble is a major character, Mrs. Maggs more marginal.

In practice, choice of *ser/estar* is often transparent from the etymology of the auxiliary: *ser* means *be something*, *estar* means *stand somewhere*. The basic rule of thumb is that predicative nouns take *ser*, predicative adverbials take *estar*. Adjectives (the undecided category here) follow the pattern of whichever of the former they are better paraphrased with. Adjectives that describe *what* something is take *ser*, those that describe *how* something is take *estar*. The unmarked choice is lexically governed, and the marked alternative, if at all used, is interpreted specially along these lines.115

Mas não havia dúvida de que aquilo *era* a Terra. *Estava* tudo ali, no pequeno disco: Londres, Atenas, Jerusalém, Shakespear.

There was no doubt that it *was* (ser) Earth. *It was* (estar) all there, on the small disk: London, Athens, Jerusalem, Shakespear.’

A largura de água entre as duas ilhas era cerca de trinta pés, e a criatura estava a menos de cem jardas dele. ‘The width of the water between the two islands *was* (ser) about thirty feet, and the creature *was* (estar) at at least a hundred yards’ distance from him’.

The *ser/estar* distinction may have granularity and existence implicatures. A permanent state typically extends past the current reference time, a temporary state typically implies a limited duration. In the perfective, a permanent state by default ends when its subject goes out of existence, a temporal one can end any time.

*ela era/estava bonita ‘she was (a) pretty (woman) in her time./ she looked pretty now’.*

*ele foi/estive doente ‘he was (a) sick (man) for life./ he had a bout of illness’*

An example of this use of the contrast is

Devo confessar-lhe que enquanto *fomos … estivemos* juntos, eu contei-lhe alguns episódios um tanto melodramáticos sobre a minha vida. *O mistério do iate desaparecido* 81.

The permanent state *fomos* entails nothing about the beginning or length of the liaison, the temporary *estivemos* implies that it was limited at both ends.

**Portuguese time adverbials**

Portuguese adverbs do not determine event type the way the English ones do. Temporal adverbs are disambiguated by aspect rather than vice versa. The English locative and durative temporal adverbs *for/in* are both translated by *durante*, and *do-a* can be translated by the durative *from-to* or by the locative *between*, depending on aspect type.116

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115For instance: *ele esta vivo/morto* ‘he is alive/dead: alive is a temporary state (‘at life’). Interestingly, age is not an accident: *ele es velho* ‘he is an old man’ (but cf. *já estas velho* ‘you are already at old age’ Santos 1996:174, *Como estava velho* ‘How old he was (looking)’ Santos 1996:349).

216In contrast, Vlach (1993:245) notes that English has no terse way to locate both the beginning and the end of the time at which a closed accomplishment takes place.
Ele escreveu o livro durante dois anos ‘He wrote (pf) the book in two years’
Ele escrevia o livro durante dois anos ‘He wrote (ipf) the book for two years’
Ele escreveu o livro do Verão ao Inverno ‘He wrote (pf) the book between spring and winter’
Ele escrevia o livro do Verão ao Inverno ‘He wrote (ipf) the book from spring to winter’.

Os sinos das igrejas tocam as vésperas quando um grupo de raparigas do Exército de Salvação descia/desceu de Waterloo Road a cantar.
‘The church bells were tolling (ipf) for evening service while/when a group of Salvation Army girls marched (ipf/pf) down Waterloo Road singing’

The distinction between absolute and relative frequency can be made with aspect in Portuguese:

Ele comeu lagosta muitas vezes ‘She ate/has eaten lobster many times’
Ele comia lagosta muitas vezes ‘She often ate lobster’.

Ele deu muitos livros às crianças. ‘He gave many books to his children.’
Ele dava muitos livros às crianças. ‘He often gave books to his children’

Ele saiu três vezes/saia três vezes por dia. ‘He went out three times (a day).
Ele saiu há dois horas. ‘He left two hours ago.’
Ele está para a há dois horas. ‘He has been out for two hours’.

This is a locus of neutralisation between perfective and perfect aspect. ‘He went out two hours ago’ is almost equivalent with ‘He has been out for two hours’ (cf. our discussion of (since) t ago).

Portuguese marks gradual approach on the verb, English on the preposition: deslocou-se a ‘moved to’ / deslocava-se a ‘moved toward, lit. was moving to’.

French

A major topic in French tense and aspect literature is the contrast between written language/literary suffixal perfective passé simple and spoken language/colloquial periphrastic perfective passé composé (Kamp 1983, Kamp/Rohrer 1983, Waugh 1990). Benveniste (1966:239ff, cf. Weinrich 1972, Hamburger 1973, Banfield 1982) described the difference between passé composé and passé simple in terms of two types of text, discours and histoire. Discours makes reference to the speech situation through personal persons and deixis; histoire is remote, i.e. unrelated to the speech situation. This may rather positively characterise passé simple than reflect negatively on passé composé, as the latter extends to the narrative and literary contexts to which the former is being confined to. But there remain contrasts supporting it. The existential perfect use of passé composé above is one. The two perfectives are nicely contrasted example from Simenon (Waugh 1990):

Maigret frotta una allumette, tirà à petites bouffées sur sa pipe. J’ai fait une partie de mes études avec Julien Chabot, enonce-t-il calmement. Plusieurs fois, jadis, j’ai été l’hôte de sa maison de la rue Clémenceau.
‘Maigret struck (ps) a match, took (ps) small puffs on his pipe. I did (pc) part of my studies with Julien Chabot, he said (ps) calmly. Several times, some time ago, I was (pc) a guest in his house on Clemenceau St.’

Another neat contrast is

Parfois, il me semble même qu’il fut l’une des multiples incarnations de mon père. J’ignore ce qu’il est devenu.
(Mondiano, Livret de famille, cited in Vet 1981: 115). ‘When did I know (p.c.) H.M.? Oh, I wasn’t (impf.) yet twenty. I often think (pres) of him. Sometimes it even seems (pres) to me that he was (p.s.) one of the many incarnations of my father. I don’t know (pres) what became (p.c.) of him.’

As Vet points out, passé simple cannot be replace passé composé in the first sentence because of the first person reference. The passé simple fut moves the scene to the past, while the last passé composé again relates the past to the present.

Formally, French passé simple is a narrative past perfective pf e’naw, denoting past events, while the passé composé is a simple perfective past pf e’now covering the ranges of perfective simple past pf e’now and perfective present perfect pf e’naw, depending on focus. The imparfait is an unmarked imperfective past ipf e’naw.

Guillaume (1929:127) gives a geometrically inspired characterization of the tense systems of written and spoken French. He generates the eight forms of the spoken language system from the Cartesian product of oppositions (pres|impf)(pres|fut|pres|perf) aimé, aimais, ai aimé, avais aimé,aimerai,aimerais,aurai aimé,aurais aimé. More peculiarly, Guillaume generates the ten forms of written French from the formula (pres|perf) | (pfl|pf)(plain|fut)(simple|perf) aimé, ai aimé; aimerai, auras aimé, aimais, avais aimé; aimerai, aura aimé, aimai, eus aimé. All things considered, the following more traditional formula seems preferable: (((fut|plain)(pres|past)) |
pf.past)(simple|perf). Its asymmetry with respect to perfective helps explain why passé simple is the weak link of the system.

**Passé composé**

Accordingly, passé composé is compatible with both present and definite past adverbials, depending on focus:

- Pierre est arrivé maintenant/le 9 septembre. ‘Pierre (has) arrived now/ on September 9.’
- J’ai perdu la clef de la maison hier; je ne peux pas ouvrir la porte. ‘I lost the house key yesterday; I can’t open the door.’

Both types of adverbs are predictably awkward together (Vet 1981:116):

- Claire est partie ce matin maintenant. ‘Claire (has) left this morning now.’

Passé composé covers existential present perfect, but not universal (continuous or extended now) perfect (Smith 1991:274). For the latter, the present tense appears. In its present perfect sense, passé composé can be evidential (second example below).

- Nous avons vécu / vivons ici depuis la guerre. ‘We have lived (pc) / live (pres) here after/since the war.’
- On dirait qu’il a plu. ‘One would say it has rained.’

It is common for passé compose to announce and summarise past events and passé simple to detail them (Waugh 1990:170):

- Je me suis evade, en 1940, avec le futur aumônier du Vercors. Nous nous retrouvames peu de temps après l’évasion… Il est mort aux Glières. ‘In 1940 I escaped (p.c.) with the future chaplain of the Vercors. We met again (p.s.) shortly afterward … He died (p.c.) on the slopes of Glières.

Stories starting directly with passé simple have the same in medias res feel to them as English story beginnings in bare simple past.

**Perfective passé compose contrasts with imperfective imparfait in**

- L’été passé ils construaient/?ont construit une cabine; peut-être qu’ils la construisent encore. ‘Last summer they were building (impf) / built (p.c.) a cabin; perhaps they are still building (pres) it.’ (Smith 1991)

However, like the Portuguese Perfeito, passé composé is a grammatical aspect in that it does not entail closure of the lexical event type, but only a closed event token in context. It is not the speech, but last night, that is over in

- Le président a parlé à la télévision hier soir, et ce matin, il parle toujours. ‘The president spoke (p.c.) on television last night, and this morning he is still speaking (pres).’

On the other hand, imparfait too can describe open event types which are over now. In the following example, passé composé criticises the total consumption last summer, while the imperfective is about daily consumption last summer (or during some particular event being talked about).

- L’été dernière vous avez bu/buviez trop. ‘Last summer you drank/used to drink/were drinking too much.’

**Passé simple**

Passé simple is excluded with proximal deictics as in Hier j’ai été/*fus à Paris ‘I was in Paris yesterday’ or Maintenant, Claire arriva ‘Now Claire arrived’ (Vet 1981). There are more or less fixed turns of phrase where passé simple is paired up with the present (Molendijk 1994, Molendijk/de Swart 1998):

- Ce fut et reste mon meilleur ami. ‘He was (pf) and remains my best friend.’
- Les hommes furent jadis ce qu’ils sont un présent. ‘Men were (pf) forever what they are now.’

The combined event type holds throughout an extended now. Passé simple still only needs to cover a proper (though not remote, Molendijk 1994) past, for French present can pick up the rest. Greek imperfect (quod vide) has a similar use.

A passé simple il fut président ‘he became/was once president’ can represent a cycle or an inception (Kamp and Rohrer 1983:259), while Il a été president ‘he was/has been president’ is not inceptive (one says Il a devenu président ‘he became/has become president’).

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217 According to Vet (1981:116) the present perfect/evidential reading is restricted to closed event types, excluding for instance Evidemment/Maintenant, Claire a admiré Paul.
The passé simple associates with adverbs indicating narrative progression: *puis* 'then, after that', *finalement* 'finally', *bientôt* 'soon', *plus tard* 'later on'. However, no more than narrative tenses in other languages, it does not automatically bring a narrative forward; that depends on implicit discourse structure.

Marie chanta et Pierre l’accompagna au piano. ‘Marie sang (ps) and Pierre accompanied (ps) her at the piano.’

Nadine s’assit et lut la lettre. Elle fut étonnée de constater que la lettre la touchait beaucoup. ‘Nadine sat down (ps) and read (ps) the letter. She was surprised (ps) to notice that the letter touched (ipf) her very much.’

Jean monta dans sa chambre. Pierre le suivit. ‘Jean went (ps) to his room. Pierre followed (ps) him.’

**Imparfait**

French imparfait appears to be an unmarked past tense in French. It is the unmarked member of the open/closed opposition with passé simple and the perfect/simple aspect opposition with passé compose. The imparfait entails that the framing event extends throughout the reference time. It may implicate but does not entail that the framing event extends past the reference time or remains uncompleted (Smith 1991:18). This recalls Hedin’s (1998) idea of an unmarked imperfective denoting the event type.

L’année dernière j’ai déménagé / je démenageais. ‘Last year I moved/spent moving house’. (Ducrot 1979)

C’est incroyable, la semaine dernière il pleuvait plusieurs fois et, cette semaine, il n’y a pas eu une goutte d’eau. ‘It is amazing, last week it often rained (ipf) but this week there hasn’t been (pc) a drop of water.’

Bien sûr, tu as montré que tu refusais ce qu’il t’offrait. Tu as refusé de fraterniser. ‘Sure, you showed (pc) that you refused (ipf) what he was offering (ipf) you. You refused (pc) to fraternise.’ (Sarraute: Fruits d’Or)

With point time adverbials, imparfait constitutes a common way to foreground an unexpected or significant turn of events (*imparfait de rupture* or *narratif*, Fludernik 1993:203). This usage of imparfait is marked by a location time adverbial that shifts narrative time forward.

Comme elle avait été à l’Opéra, une nuit d’hiver, elle rentrait toute frissonnante de froid. *Le lendemain* elle toussait. *Huit jours plus tard* elle mourait d’une fluxion de poitrine.

‘As she had been to the Opera one winter night, she returned (ps) home completely shivering with cold. The next day she was coughing (ipf). *A week later* she was (already) dying/died (ipf) of pneumonia.

*Un mois plus tard*, elle signait le contrat de vente et achetait en même temps une petite maison bourgeois. ‘A month later she was signing/signed (ipf) the sales contract and was buying/bought (ipf) at the same time a small house.’

This type of “imparfait of final consequence” suits the purpose of finishing a sequence of events because unlike perfective, imperfective does not raise the question and then what? There is a suggestion of vividness and narrative presence involved too. Unlike English picturesque progressive, *imparfait de rupture* allows simple changes (Touratier 1997:23). This may give the form a resultative feel (Desclés 1994:83).

Une heure après, il prenait le train pour Paris. ‘One hour later, he took (ipf) the train to Paris.’ (Martin du Gard, *Les Thibault*, III, 52)

Tout changeait à cinq heures par l’arrivée de Desaix. ‘Everything (had) changed (ipf) in five hours with the arrival of Desaix. (Bainville, *Napoléon*, 176)

Fidèle à sa promesse, Salomon envoyait le même soir l’article du docteur Nathan à Per. ‘Faithful to his promise, Salomon sent (ipf) Per Dr. Nathan’s article the same evening. (Pontoppidan, *Pierre de Chanceux*.)

In the beginning of a narrative, an *imparfait pittoresque* locates the reader in the middle of the events (Lerch 1922, Pollak 1960, cf. section on perception in narratives). Note the concomitant perceptual vocabulary (sombre ‘dark’).

Le 4 septembre 1768, naissait à Saint-Malo, dans la sombre rue des Juifs, le chevalier François de Chateaubriand.

‘On September 4, 1768, F.d.C. was born (ipf) on the dark street of rue des Juifs.’


L’imparfait n’est pas comme on le dit parfois trop sommairement le temps de la durée, mais de l’action envisagée en dehors de son commencement et de sa fin. ‘C’est pourquoi il est le temps de la description. C’est pourquoi aussi il ne peut jamais s’employer avec l’indication de la durée, car si la durée peut être mesurée, c’est qu’elle est révolue. On peut dire *Il habitait Londres pendant la guerre*, mais non *Il habitait Londres pendant dix ans*.'
As Vinay and Darbelnet point out, *pendant* is dually vague in French. The first *pendant* is loose 'He lived in London during the war', the second tight 'He lived in London for ten years'. (Cf. similar observations about *durante* in Portuguese.) On the other hand, the received wisdom (Smith 1991:11, Kamp/Rohrer 1989:15-16, Lyons 1978:709-710) is that both senses are available with

- *Il regna pendant trente ans.* 'He reigned (ps) for thirty years.'  
- *Il regnait pendant trente ans.* 'He reigned (impf) during thirty years.'

Intuitively, the passé simple presents the event as closed off (against some background), while the imperfect represents it as open (background to something else). The relation of the event and its reference time is accordingly different: the perfective locates the reign within the reference time, the imperfective locates reference time within the reign. This is not just a loose metaphor but the literal content of the formulas on the right: perfective ('~reign.reign\(30\)ans) versus imperfective *reign?(reign\(30\)ans)*.

The constraint seems to be that French *pendant* meaning 'for' excludes imperfect: Rohrer (1981) stars *Jean traversait l'Atlantique pendant deux jours* 'John was traversing the Atlantic for two days', and Vet (1981) *Jeanne copiait la lettre pendant des heures* 'Jeanne was copying the letter for hours'. According to Johanson (1998:§10.2.1.1) an object like duration adverbial unambiguously requires perfective: *Il regnait*\(30\)ans* 'He reigned thirty years'.

Imparfait is also the ‘present in the past’ of indirect discourse; it allows the personal perspective deictic *maintenant* 'now' of style indirect libre:

- *Maintenant ils etaient prêts.* 'Now they were ready (ipf).'
- *Maintenant/A ce moment il partit/a été parti.* *Now/at this moment he left (pf).*

Imparfait gets future meaning with achievements: It is the form to use for bound past future:

- *Tout le monde entra: le ministre arrivait.* 'Everyone entered (pf); the minister was arriving (ipf).'
- *Perre se dépêcha. Son train partait dans cinq minutes.* 'Pierre hurried (ps). His train was leaving (ipf) in five minutes.'
- *Je ne sais pas si je t'ai dit que Jeanne venait déjeuner mardi.* 'I don't know if I told you that Jeanne is coming to lunch on Tuesday.'

Present tense appears in English when the dinner is factually nonpast. In French, perfective past *a venu* would indexically refer to a past Tuesday.

Eberle and Kasper (1994) apply discourse representation theory to French tense and aspect, in particular, to the contrast between passé simple/composé and imperfect. They list the following principles:

1. The passé simple drives the narrative’s action forward, the imperfect is incapable of this.
2. The passé simple presents an event as punctual, while the imperfect presents the state or condition it reports as extended.
3. The passé simple presents the event it introduces as temporally closed; the imperfect presents the state it introduces as temporally open.
4. The imperfect presents the state it describes from within, whereas the passé simple presents the event it describes from a distance, and, by implication, from outside.

These principles are also covered by my formalisations (to the extent they hold true).

Molendijk (1994:26) wants to capture the difference between imperfect and passé simple by saying that the former conveys "global simultaneity", while the latter never has this property. Molendijk's relation of global simultaneity of *e* and *f* translates to *e in f* in the present calculus. This is fine by me, for *e in f* is equivalent to *e at f* for open event types *f* (but not for closed event types).

An interesting minimal pair contrasting time within and between sentences is (Molendijk 1993)

- *Quand, finalement, il traça le cercle, ce fut un cercle bizarre.* 'When, finally, he drew the circle, it became (pf) a bizarre one.'  
  *draw\(\land\)circle.circle\(\not\oddf\)*
- *Finalement il traça le cercle.* 'He finally drew the circle. It was (ipf) a bizarre one.
  *draw\(\land\)circle.circle \A circle\(\notf\)*

The sentence matches two closed events (*the circle he drew became bizarre*). Imparfait is out because the circle is not there until the end of the drawing (Irandoust 1994:73). The discourse interpolates a question about the consequent state *What was it like then?*

**Pluparfait and passé antérieur**

French allows an opposition between an imperfective past perfect (pluparfait *avait chassé*) and a perfective past perfect (passé antérieur *eut chassé*). Passé antérieur is a remote perfective perfect (*pf perf e*) *now*. According to Kamp/Rohrer
(1983), it appears in main clauses only with time adverbials like vite 'quickly', en moins de rien 'in no time'. This makes sense, for given the irrevocability of perfect, the only way to close one is to give it a time bound. Johanson (1998:§8.7) provides examples of perfective perfects in other languages with a similar eo ipso implicature.

En moins de rien Marie eut terminé son travail. ‘Mary had finished her work in no time.’

As a perfective, the passé antérieur in a quand clause sequences events.

Enfin elle referma ma porte. Quand elle eut verrouillé la sienne, je regagnai, dans le cabinet de toilette, mon poste d’écoute. ‘At last she closed (ps) my door. When (after) she had locked (pa) hers, I returned to my listening post in the toilet.’

With the imperfective pluparfait, we have a flashback. Thus pluparfait cannot be replaced by passé antérieur in flashbacks (Kamp and Rohrer 1983:258):

Cunégonde s’évanouit. Son père avait/eut chassé Candide du château à grands coups de pied dans le derrière.

‘Candide fainted. His father had driven Candide out of the castle with hefty kicks on his backside.’

In spoken French, passé antérieur is replaced by a double perfect form j’ai eu ecrit known as passé surcomposé (Valin 1965, Harris/Vincent 1988:229):

Quand nous avons eu marché pendant deux heures, nous avons demandé au guide si nous arrivions.

Présent and futur

The French present tense does not distinguish aspect. Accordingly, the present covers all stative event types (simple state, dynamic state or progressive, and generic state or habitual). Jean mange des pommes translates John eats/is eating apples. Optionally, a progressive reading can be marked out by periphrases: John est en train de manger des pommes ‘John is in the process of eating apples’, but that is making a special point of it. Like German, unlike English, French allows Ce soir, j’ai terminé la lettre ‘I will have finished (pres perf) the letter tonight.’ (Johanson 1998:8.3).

French has an inflectional remote future now<e Que será, será ‘What will be, will be’ and a periphrastic near future now.e Je vais la voir ‘I’m going to see her’. (Vinay and Darbelnet 1975:§114). The difference is clear in Il a l’air d’un homme qui va mourir/mourra ‘He looks like a man who is going to die/will eventually die’ (Vet 1994:83): the latter relative clause seems inane.

There is also a difference in grammaticalisation. The remote future can be bound to another future, the near future can not:

Quand il va pleuvoir les enfants sont assomments. ‘When it is about to rain the children are annoying.’

annoying[f]<rain

Quand il pleuvra les enfants seront assomments. ‘When it eventually rains the children will be annoying.’

now<rain[annoying

Almost symmetrically, Il vient de arriver ‘He has just arrived (lit. he comes from arriving)’ marks near past. Future in the past is represented by the conditional (etymologically a past future) or the imperfective past of the near future:

Pierre savait/sut/su que Marie disparaitrait/allaït disparaître bientôt. ‘Pierre knew that Marie would/was going to disappear soon.’

Sequence of tenses

Sequence of tense in French (Rohrer 1985) works in many respects as it does in English. Lack of sequence indicates de re reference.

Pierre a dit hier que Marie viendra/viendrait. ‘Pierre said yesterday that Marie will/would come.’

Le jeune fille dit qu’elle étudiait/étudie la linguistique. ‘The young girl said that she studied/studies linguistics.’

M. Kurt Rebmann a déclaré à Karlsruhe que le parquet fédéral disposait d’indices prouvant que l’agression don’t a été victime M. Zimmermann avait été commise par des membres de la Fraction Armée Rouge.

‘Mr. Kurt Rebmann declared in Karlsruhe that the federal attorney had indications proving that the aggression which Mr. Zimmerman has suffered had been committed by members of Fraction Armée Rouge. The aggression is a fact, the identity of the evildoers an allegation.’
Vinay and Darbelnet (1975:§132) observe that French is more exigent about sequence of tense than English. French must use the pluperfect rather than passé simple in a narrative context when event time precedes reference time: This means that French passé simple can be neither quoted nor free.

He asked us when we came. ‘Il nous demanda quand nous étions arrivés.

Driving a peg into the ground at the precise spot where the beetle fell… (Edgar A. Poe) ‘Enfonçant un piquet dans le sol à l’endroit même où le scarabée était tombé.’

In temporal clauses passé antérieur eut achevé cannot be replaced by passé simple acheva.

Quand il eut achevé/*acheva son article, il l’envoya à l’éditeur. ‘When he (had) finished his article, he sent it to the editor.’ (Rohrer 1985)

A pluperfect flashback can (and must) have pluperfect all through:

Quand il avait achevé son article, il l’avait envoyé à l’éditeur. ‘When he had finished his article, he had sent it to the editor.’

German

Among the objects of interest in the German tense and aspect system are the contrast between simple past (preterit) and present perfect, where the perfect is taking over narrative functions from the simple past, and the wide range of the simple present, covering simple and progressive aspect, present, future, and cases of extended present (universal perfect).

Fuchs (1988) rightly emphasises paradigm and markedness considerations here: the perfect is marked for completion, the simple past for definiteness, while the present is the leftover tense. The future auxiliary werden is still markedly modal. The German present perfect is a perfective simple past pf e<now and the preterit as a definite past ef[then]<now (Ballweg 1989, Thieroff 1994). Unmarked for focus, the present perfect thus subsumes a definite past ef[then]<now as well as an existential perfect e<then>now. For a review of the German TA debate cf. Ehrich/Vater (1989).

Preterit, perfect and pluperfect

There are the usual indications that the German perfect is perfective. The German present perfect is not marked for reference time (it is used for a present perfect as well as a narrative tense), so it allows both present (reference time) and past (event time) adverbials. A present time adverbial can ambiguously indicate reference time or event time as in English, but a past one denotes event time, as the formula predicts (Thieroff 1994:111):

Gestern sind wir klettern gewesen. ‘We were out climbing yesterday.’
Manche Erholungsgebiete haben die Grenzen ihrer Belastbarkeit heute erreicht oder überschritten. ‘Many recreation areas have reached or exceeded their capacity today.’
Ich habe heute zwei Achttausender bestiegen (und also nur noch 14 vor mir/und bin schrecklich müde). ‘I have climbed two eight thousand meter tops today (so there are 14 to go/and I am awfully tired).’

It allows schon ‘already’ but not immer (nur) ‘still’ (Thieroff 1994): Open event types are not ruled out. Result implicatures are cancellable.

Jetzt hat es endlich geschneit und es schneit immer noch/der Schnee ist aber gleich geschmolzen. ‘Now it has finally snowed, and it is still snowing/but the snow melted away immediately’.

Yet according to Fuchs (1988) and Ehrich/Vater (1989), perfect is preferred for closed event types, simple past for open ones.

Goethe war ein grosser Dichter. ‘Goethe was (pret) a great poet.’
Goethe ist zweimal in der Schweiz gewesen. ‘Goethe was (perf) twice in Switzerland.

Deine Haare sind ja ganz Nass! ‘Your hair is all wet!’
Ich war unter der Dusche. ‘I was (pret) in the shower.’/ Der Peter hat mir einen Becher Wasser übergegossen. ‘Peter poured (perf) water on me.’

The following example (Ballweg 1989) shows a live present perfect/simple past contrast: the simple past reports a remote past event, the perfect an extended now.

Aber dass mein Mann mich nahm, trotz einem Kind, dass er Angela ein liebevoller Vater geworden ist, der keinen Unterschied gemacht hat zwischen ihr und seinen eigenen Kindern, dass weissst du nicht.
‘What you don’t know is that my husband took (pret) me in spite of the child, and that he has become (perf) a loving father to Angela, who has made (perf) no distinction between her and his own children.’
In oral narrative main clauses, the preterit and perfect are largely interchangeable particularly in south German (Lindgren 1957). In written narrative, judging from Fludernik (1993:211), a recit/discours type opposition (whether the point of reference is past or present) persists. It surfaces in a contrast between bound simple pasts in temporal adverbiacl clauses and inside narrative, perfects in main clauses and narrative summaries.

Bevor Schmidt seinen Auslandseinsatz antrat, hat er geheiratet. ‘Before S. entered (pret) his overseas duty, he married (perf).’

Ich wollte Fenster putzen. Damit ich von aussen an das Fenster herankommen konnte, legte ich ein Bügelbrett auf die Fensterbank. Mein Mann, der schwerer als ich ist, setzte sich innen auf das Bügelbrett, und ich putzte auf dem Brett stehend das Fenster von aussen. Plötzlich klingelte es an der Haustür. Als mein Mann unten öffnete, fand er mich vor dem Eingang liegend. Wir wissen bis heute nicht, wer geklingelt hat. ‘I wanted (pret) to clean the windows. In order to get at the outside of the window, I put (pret) an ironing board on the window sill. My husband, who is heavier than me, sat (pret) on the board on the inside, and I stood (pret) on the board on the outside and washed (pret) the window. Suddenly the doorbell rang (pret) downstairs. When my husband opened (pret) the door, he found (pret) me lying on the doorstep. We don’t know (pres) to this day who rang (perf) the bell.’

Als ich seine Gedichte erstenmal las, dachte ich: Nun, das erscheint mir nicht besonders schwer; jeder kann Dichter werden. Daraufhin hab’ ich’s selbst versucht. Es ist alles andere als einfach. Meine Reime taugten überhaupt nichts. ‘When I first read (pret) his poems, I thought (pret): now that does not seem particularly hard, anyone can become a poet. So I tried (perf) it myself. It is anything but simple. My rhymes were (pret) no good.’

Unlike the English perfect, a German present perfect can be future or generic (Latzel 1974, Grewendorf 1982:77, Declerck 1994:95). This is consistent with the wider range of present tense in German.

Hans hat das Problem morgen gelöst. ‘Hans will have solved (pres perf) the problem tomorrow.’

Ein Unglück ist schnell geschehen. ‘An accident has soon happened (pres perf).’ Cf. ‘A mistake is quickly made.’

There is a passive present result perfect in (Johanson 1998:§8.5.1.1): gestern is infelicitous without worden

Er ist gestern verhaftet *(worden). ‘He has been arrested yesterday’.

The German pluperfect can be simply composed as the past tense of the present perfect (Thieroff 1994:111). It allows adverbials on both event time and event time (Vennemann 1987, Ballweg 1988:88, Thieroff 1994:109): Am 1/2 September 1939 hatte Hitler Polen überfallen. ‘On Sept 1/2, 1939, Hitler had attacked Poland. The position of the adverb helps tell which: Bill war schon um Acht gegangen ‘Bill had left already at eight’ vs. Um acht war Bill schon gegangen ‘at eight Bill was already gone.’ (Thieroff 1994:110).

**Present**

German has no grammatical progressive. A sentence like Er ass/isst einen Apfel is simply vague about completion. The modal adverb gerade is one of the many substitutes (Löbner 1988:187). Cooper (1986) proposes that languages with a present tense like German have a weaker rule for matching event with discourse location, by which it is enough for the discourse location to be surrounded by the present tensed event type. A descriptively equivalent solution is that a form which does not mark aspect is open to unmarked imperfective/perfective aspect shift.

Another indication that German present perfect is perfective is that it cannot replace the present in sentences with seit ‘since’, except in the scope of negation.

Seit dem letzten Monat bekomme ich keine Nachrichten von ihm. ‘I have had (pres) no news of him since last month.’

Deshalb stehe ich schon so lange vor dem Tigerkäfig. ‘That is why I have already stood (pres) so long outside the tiger’s cage.’

Seit drei Jahren rauche ich nicht mehr. ‘I have not smoked for three years.’

Ich habe seit drei Jahren nicht mehr geraucht ‘I have not smoked in three years.’

There is a considerable number of lexically governed constructions in German for spelling out progressive aspect (Ebert 1989):

Gestern waren wir klettern. ‘We were out climbing yesterday’.

Alex baute an einem Haus. ‘Alex was building at a house.’

Er war dabei, Ockes Hühnerhaus wieder aufzubauen. ‘He was busy with rebuilding Ocke’s chicken coop.’

Als ich nach Hause kam, schälte sie gerade Kartoffeln. ‘When I came home she was just peeling potatoes.’
Die Kartoffeln stehen schon zu kochen. ‘The potatoes are already on the boil.’
Ich war gerade am Einschlafen. ‘I was about to fall asleep.’

A curious case of resultative present (Brugmann 1913:739) is the use of the present with gestern ‘yesterday’ in

Ich erhalte gestern eine Mahnung über ausstehende Beiträge. ‘I receive (pres) yesterday a reminder of outstanding contributions.’

Erhalten ‘get’ is an inceptive derivative on halten ‘hold’. In English too, some acquisitions alternate between present and perfect tense: I hear/read in the papers can mean I have heard/read (Joos 1967:145).

**Sequence of tenses**

Fabricius-Hansen (1989) shows that German applies three sequencing principles, as exemplified by the following examples:

*(quoted)*

Wir hatten alle Angst, dass sie den Lastwagenfahrer mitnehmen. ‘We were (pret) all afraid that they would take (pres) the truck driver along.’
Ich sass am Filmabend des Frauenvereins hinter Ihnen. Sie fragten mich, ob mich Ihr hut stört. ‘I sat behind you in the Ladies’ Club film show. You asked (pret) me if your hat bothered (pres) me.’

*(free)*

Anna teilte mir heute morgen mit, dass Hans diese Woche verreist ist. ‘Anna told (pret) me this morning that Hans is (pres) away this week.’
Ein bisschen später hörte ich vom Sheriff, dass ausgerechnet dieser Bursche zur Zeit in einem Schienenlager ganz in der Nähe war. ‘A little later I heard (pret) from the Sheriff that this particular dude was (pret) in a nearby railroad camp at the time. (i.e. had been)
Eine halbe Seite, die mich über eine Stunde gekostet hat, hatte ich zerknüllt in den Papierkorb geworfen! ‘I had crumpled and thrown away (pret perf) a half page that took (pres perf) me over an hour.’

*(shifted)*

Ike Force dachte, dass dieser Stich tödlich war, wenn er nicht dafür sorgte, dass der größte Teil des eingespritzten Giftes nicht in die Blutbahn kam. ‘Ike Force thought that this bite was (pret) deadly unless he made (pret) sure that most of the injected venom did not enter (pret) the circulation.’
Tonio erfuh dor, dass Kids aus Washington eigens hergekommen waren, um sich in New York den Boxkampf anzusehen. ‘Tonio found out (pret) there that Kids had come (pret perf) Washington specifically to watch the boxing fight in New York.

An indicative preterit can represent a bound past future if governing context is nonquotative, like warten ‘wait’, sorgen ‘make sure’, damit ‘in order to’. In quotative contexts, a subjunctive past future appears. Here German contrasts with Scandinavian languages which have lost a separate subjunctive:

Hans wartete darauf, dass der Bus kam. ‘Hans waited for the bus to come.’
Hans sagte gestern, dass er heute wiederkäme/wiederkommen würde/*wiederkam. ‘Hans said yesterday that he was coming (subj) /would come (past fut) again today.’
Hans sade igår att han kom/skulle komma tillbaka idag. ‘Hans said yesterday that he was coming (pret) / would come (past fut) back today’

**Double perfect**

As in French passé surcomposé, the drift of the present perfect toward a simple past tense shows in the appearance of double perfect:

Ich hab dich eingeschlossen gehabt! ‘I have had you locked in.’
Das hatte der Verfasser schon gesagt gehabt. ‘The author had already had it said.’
Die Woche zuvor hatte Lily Gewicht verloren gehabt. ‘Lily had had some weight lost the previous week.’
Russian

Russian has a lexicalised system of partly derivational, partly suppletive open-closed verb aspect pairs. Following Forsyth (1970), Lindstedt (1985:151) lists alternation types by aspect type as follows:

- Unpaired perfectives, e.g. ruxnut ‘collapse’
- Momentaneous-iterative pairs, e.g. naiditi/maxodit ‘find’
- Achievement-process pairs, e.g. umirat/umeret ‘die’
- Activity-accomplishment pairs, e.g. pisat’napisat ‘write’
- State-acquisition pairs, e.g. ponimat’/ponjat ‘understand’
- Unpaired imperfectives, e.g. imet ‘have’, znachit ‘mean’

Morphologically marked perfectives are formed by adverbial result prefixes and semelfactive -nu- suffixation. Prefixes in general retain adverbial or prepositional meanings (e.g. do ‘up to’, iz ‘out of’, na ‘on’, ob ‘against’, ot ‘away’, pere ‘across’, pod ‘under’, pred ‘before’, pri ‘near’, po ‘by’, pro ‘through’, raz ‘apart’, so ‘down’, u ‘off’, voz ‘up’, vy ‘out’, za ‘after’), but seem purely aspectual when the meaning of the prefix agrees with the root (Cohen 1989:252). True to their source as result adverbs, many aspect prefixes produce changes, picking out an initial boundary (plakat ‘cry/start crying’) or a final boundary (risovat – dorisovat ‘draw/finish drawing’), but some include both boundaries, producing accomplishments or cycles (chitat – prochitat ‘read all/some’).

Marked imperfectives are formed by iterative suffixation with -(iv)u-. Suffixal imperfectives can be formed on top of preflexal perfectives. This is likely to happen when the prefix is lexicalised into the meaning of the verb (Cohen 1989:260). For example, kurit ‘smoke’ ‘smoke’, vykurit ‘pf smoke’ ‘smoke through’, vykurivat ‘pf smoke through iteratively’:

> On kazhdýj den’ vykurivajet sorok papiros ‘He goes through forty cigarettes per day’.

> On pozapiraj vse dveri. ‘He locked all the doors one after the other.’

This is a straightforward iteration of a perfective (vy+kur)=iva. pf ‘smoke’ Cf. also pobalivat ‘(po+bol)+iva pf ‘ache ‘ache intermittently’ from po+bolet ‘ache for a while’. This combination has become an aspect marker for series (Forsyth 1970:§6.3.1): pobygvat ‘pf’ be ‘pay visits’, povytolkat ‘mashki ‘throw bags away one by one’, Smith 1991:299). Suffixal imperfectives of imperfectives generate habituals like govarivat ‘speak repeatedly’. The secondary imperfective sîzhyval ‘used to sit’ is a remote habitual past. Marked imperfectives are one case where the received ‘aspect pair’ account of Russian aspect (Forsyth 1970:168) falls short of giving the complete picture (Bache 1985:68).

Smith (1991:301) maintains there are no perfective statives in Russian. There are: inceptions and cycles get formed out of states, e.g. videt’/avidet ‘see/spot’, ponimat’/ponjat ‘understand/realize’ (Rassudova 1967:15,116). The productive aspectual prefixes po-, pro-, do- apply to states: pobyt ‘be for a time’, pozhit ‘live for a time’, prozhit ‘live through a time’, dozhit ‘live until a time’, (po)nranvat sju ‘begin to please’ (for a time).

Lindstedt (1985:47), following Leinonen (1982), reviews four theories of the perfective-imperfective distinction in Slavic languages, whose respective key notions are (i) punctuality, (ii) resultativity, (iii), boundedness, and (iv) totality. Theory (i) says perfective expresses punctuality, imperfective durativity. Lindstedt considers it outdated. The so-called delimitative or perdurative perfectives entail duration, as in Russian prospal dva chasa ‘he slept two hours’. We have seen that this theory too has a certain justification in terms of scale and granularity. Lindstedt is right, however, in that generally duration (extent) is a metric concept, and the perfective-imperfective distinction is not.

Lindstedt wonders what evidence we have that an event is viewed as a point, apart from the fact that a perfective verb is used. One was pointed out in the section on before and after it is the fact that Don’t return the book before I read it tends to mean the same as Return the book only after I read it. Another bit was found in the section on duration adverbials: they measure the result state if and only if the change is pointlike (e.g. close shop for a month).

Theory (ii), that the perfective expresses resultativity, Lindstedt deems antiquated too. Counterexamples are the same delimitative and perdurative verbs: Popaxali pole, no ne vspaxali ego ‘They plowed the field a while but did not plow it all.’ My solution is to eat the cake and have it by defining result in a polymorphic way. By my definitions, the result reduces to insufficiency in the relevant range of cases (cycles of open events, denoted by delimitative and perdurative verbs.)

Theory (iii) boundedness (closure in my terms) is favored in modern Russian aspectology. According to §1386 of the new Academic Grammar of Russian, perfective verbs ‘designate an integral action bounded by a limit’. Lindstedt makes this more precise: a perfective verb bounds a situation with at least one limit, but two limits are also possible.

Often, the limit is the transition to a new state, but the limit can be imposed on the action from outside.

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218 According to a calculation reported in Leinonen (1982:17), one third of Russian verbs are unpaired, and one in twenty is biaaspectual.

219 Smith (1991:316) claims that adding a prefix always produces a perfective verb. But of course there are lexicalised exceptions denoting states, e.g. pred-videt ‘foresee’, raz-umet ‘reason’ (Cohen 1989:261).
Totality (iv) is a Boolean notion. Lindstedt's quote from de Saussure (1916) shows that viewpoint aspect is intended: “le perfectif représente l’action dans sa totalité, comme un point, en dehors de tout devenir; l’imperfectif la montre en train de se faire, et sur la ligne du temps.” I have argued that viewpoint aspect is a combination of the open/closed distinction with indexical tense.

**Russian aspects**

It is sometimes maintained that Slavic aspects mean something different from what aspects do in (say) Romance languages. I think this is wrong. Precisely the same semantic distinctions are at issue (Lindstedt 1985:§2.6,3.2, Chung/Timberlake 1985). The imperfective views events in their parts (in progress, iterated, incomplete, or as mere happenings), the perfective views them as wholes (completed or successful). Differences concern grammaticalisation, markedness and the combinatorics of aspects with other inflections, including tense. (Dahl 1985:89, Thieroff 1994:32).

There is a tradition in Russian aspectology to enumerate Aktionsarten (ru. sposoby dejstvija), i.e. occasional or particular aspect meanings of the perfective and imperfective (Rassudova 1967:14). As Lindstedt (1985:55) points out, such meanings are common and possibly conventionalised event types associated with the aspects. The number of types distinguished depends on the level of abstraction chosen: the finer the context distinctions, the more meanings are found. This is analogous to classifying lexical aspect or diathesis types, or, for that matter, to classifying uses of discourse particles (Carlson 1984).

Particularly interesting phenomena in Russian aspectology from a systematic point of view are cases of aspecual competition, in which different aspects seem to come close to saying the same thing. Any aspect theory worth its mettle should explain such cases: what is the same and what (if any) stays different. There are many such situations in Russian between the perfective and imperfective aspects.

In Russian, the perfective is usually the marked member of a privative opposition (Jakobson 19321957:48, Forsyth 1970, Leinonen 1982:38ff, Chung/Timberlake 1985). Morphologically unmarked forms can be open or closed, for instance spat ‘sleep’, bit ‘hit (once or more)’, terjat ‘lose (once or more)’. Forms morphologically marked for perfective only have closed readings, for instance, cycle po-spat ‘sleep for a while’, u-bit ‘kill’, po-terjat ‘lose once’. This is a major typological difference between Portuguese and Russian: In Portuguese, the imperfective is marked and used for backgrounding, while the perfective is unmarked and used for both perfect and narration. In Russian, the imperfective is unmarked and used both for perfect and backgrounding, while the perfective is markedly definite and used for narration. Examples of perfect uses of the imperfective preterit:

Vy konfety probovali? Proboval, hotja tol’ko raz. ‘Have you ever tasted (ipf) chocolates? I have (ipf), though only once.
Ja ne ljubila ni razu v zhizni. ‘I have not loved (ipf) once in my life.’

This is the endlessly debated 'general-factual' or 'simple denotation' imperfective of Russian aspectology (Lindstedt 1995, Bertinetto/Delfitto 1998).

Perfeito would be used here in Portuguese:

**pt** Provaste doces? Provei, embora só uma vez. ‘Have you ever tasted (pf) chocolates? I have (pf), though only once.’

**pt** Não amei nem sequer uma vez na minha vida. ‘I have not loved (pf) once in my life.’

As noted, the markedness claim is something of a simplification for Russian (Chaput 1990:288, Flier/Brecht 1985). There are also forms morphologically marked for imperfective, for instance, secondary suffixal or suppletive imperfectives ubivat ‘be killing, kill repeatedly’, naxadit ‘find repeatedly’, vidat ‘see once or more’. They too allow an existential perfective sense, which confirms that this reading is a degenerate case of iteration 'at least once' (Bertinetto/Delfitto 1998).

Russian performative sentences (those that fit nastojashchim 'hereby') are imperfective (Koschmieder 1934:37, Sheljakin 1980, Leinonen 1982:248ff). Metalanguage announcements like I will tell you, I beg you, I shall not go into or I will end here are perfective, but they are not performative either (the act follows the announcement). Sometimes the difference is small, but may still be there: *must ask* and *ask* are not interchangeable in English either in

Zdes' medicinskoje uchrezhdienie. Postoronnyx poproshu udalit'sja - skazal on. ‘He said: This is a medical establishment. I must ask (pf pres) outsiders to leave (pf).’

On poserjeznel i zasuchal pal'cami po stolu. - Proshu prav'ilno menja ponjat'. Rech' poizd o fel'dshehere
Zavidonove. ‘His face grew serious and he taped his fingers on the desk. ‘I ask (ipf pres) you to understand (pf) me correctly. I'm talking about Zavidonov the medical auxiliary.’
Negation

The existential perfect use of imperfective preterit is particularly common in yes-no questions (Rassudova 1967, Leinonen 1982, Chung/Timberlake 1985, Chaput 1990). This suggests that a negative polarity (presupposition) phenomenon is involved. Examples:

Vy smotreli etot fil’m? ‘Have you seen (ipf) this film?’
Nu kak, vy posmotreli fil’ ‘Devjat’ dnej odnogo goda? ‘Well, did you watch (pf) the film ‘Nine days of a year’?
Vy chitali ego novyj roman? ‘Have you read (ipf) his new novel (or not)?
Vy prochitali ego novyj roman? ‘Did you finish (pf) his new novel?’

English uses the perfect, Russian uses the imperfective preterit in a presupposition free question about the past. The imperfective just inquires about the existence of an event, while the perfective presupposes an identifiable time. (Note also the resumptive *nu kak/well*).

Reading a book is a three way distinction: one reads it all, reads a part, or reads none of it. The perfective question frames a disjunction between reading all of it or not, which already presupposes some reading, while the imperfective question offers a choice between no reading at all and some reading, with an empty presupposition (Rassudova 1967:62, Forsyth 1970:112. Smith 1991:335).

Given that the perfective presupposes the occasion and asserts completion, it has a success sense ‘manage’, opposed to the conative imperfective ‘try’. As the completion of a closed event presupposes an initial state; it makes sense to deny the closure only if the initial state holds.

Ja eshche ne (pro)chital etu stat’ju. ‘I have not yet read any/all of this paper.’
Kolja ego ne dogonjal/dognal. ‘Kolja did not try/manage to catch him.’

These observations follow from logical properties of open/closed events. An open event type is upward persistent, so its negation is downward persistent. Reading equals reading something; if I did not read even a little, I did not read at all (Smith 1991:336). Thus the imperfective question/denial is innocent, the perfective is loaded (Merrill 1990:30-31). This shows in courtroom questioning (Forsyth 1970, Chaput 1990:295):

Vy vzjali nozh? - Ja ne brala. ‘Did you take (pf) the knife?’ ‘I have not taken (ipf) (anything).’

Recall similar examples in English, where the use of the simple past presupposes some appointed time for the event, whose denial demands the perfect. In Finnish, an innocent question uses a partitive object; the total object question is loaded, presupposing that Jussi is around.

Oletko nähnyt Jussia/Jussin? ‘Have you seen Jussi (prt = at all/gen = yet)?’

The difference between denying one particular event and any event at all is also in evidence in

Kolja nichego ne naxodil/nashel. ‘Kolja did not find anything (pf: at all/pf: that time).’
Kolja ne nashel (?) naxodil kljuch. ‘Kolja did not find the key (pf: then/ipf: ?at all).’

Here, a singular count object makes a generic denial unlikely. Russian aspect can thereby translate definite vs. indefinite anaphora in English (Forsyth 1970:102).

Vy poluchili moe pis’mo? Ne poluchil/poluchal. ‘Did you receive my letter? I didn’t receive it (pf) /I haven’t received any (ipf).’

On the other hand, if the existential and uniqueness presupposition is satisfied, the two aspects appear interchangeable (a case of aspectual competition). Chaput (1990:296) notes that such competitions are frequent in event types denoting regular cyclic process such as eating, sleeping, etc, which happen at appointed times:

Ty zavodil/zavel chasy? ‘Have you wound up/did you wind up the clock?’
Ja ne goloden, Ja uzhe obedal/poobedal ‘I am not hungry, I (have) already had dinner.’

The perfective-imperfective distinction, by contrasting event and process, may thus distinguish between inferential meaning and explanation, summary and detail, outcome (what) and manner of execution (how), opening and follow-up:

Kak vy provodili voskresen’e? ‘How did you spend (ipf) Sunday? (What were you doing?)’
Kak vy proveli voskresen’e? ‘How did you spend (pf) Sunday? (Did you have a good time?)’
Vtoroi poslednij den’ soveshchanie provodili/proshel bolee chino. ‘On the second and final day, the meeting went on (ipf) / went through (pf) more decorously.’
V etoj porternoj ja obdumyval svoju dissertaciju i napisal pervoe ljubovnoje pis’mo k Vere. *Pisal karandashom. ‘In this tavern I thought about my thesis and wrote (pf) my first love letter to Vera. I wrote (ipf) it in pencil.*
**Russian imperfective**

These facts are explained by noting that the Russian unmarked imperfective subsumes all the subcases of generic imperfective gen prog e, which covers as special or degenerate cases progressive, iterative, transient, and existential uses. We really need not know for sure which one of the different uses is at issue in each case, as long as all (and only) the conceivable ones are covered by the formula. The uses are not separate senses of an ambiguous form, but alternative uses of a vague one.

**Progressive**

The usual progressive use of imperfective as a frame is the special case prog e where e+ reduces to e:

Kogda ja voshel, on chital gazetu/spal/xodil po komnate. ‘When I went in (pf), he was reading a newspaper/sleeping/walking to and fro in the room (ipf).’

As Leinonen (1982:37ff) and Smith (1991:326) note, the imminent future and conative readings of the imperfective are special cases of progressive for (agentive) achievements.

On tonul, no ego spasli. ‘He was drowning (ipf), but they saved (pf) him.’

On umiraet. ‘He is dying (ipf).’

Iz ego gorla vryvatsja krik, no ne vyrvalsja. ‘From his throat a cry was ripping forth (ipf), but it did not come out (pf).’

Oni ne ugovorili ee ujti s nimi, xotja dolgo ugovarivali. ‘They did not persuade (pf) her to leave with them, although they tried to persuade (ipf) her for a long time. (Smith 1991:310)

Imperfective lends many turns of speech a friendlier, laid-back tone, like the English progressive (Forsyth 1970:§5.2, 7.4.1).

Kogda vy konchite vygruzku? Pjatnadcatogo budem konchat’. ‘When will you finish (pf) unloading? ‘We’ll be finishing (ipf) on the fifteenth.’

… Beri von nozh, kartoshku dochishchaj, a ja klubniki soberu k uzhinu. - S treťej gradki brat’ budem, ta osobenno xorosha. ‘Take (ipf) the knife and finish (ipf) the potatoes, I’ll pick (pf) some strawberries for dinner. - We’ll be taking (ipf) them from the third bed, it is especially good’.

Perfective and imperfective are opposed quite predictably in imperatives. Imperfective imperatives can mean keep/get Ving: kurite ‘Keep smoking, don’t let me stop you’, byvaj zdorov ‘Take care (ipf) of yourself’ (lit. stay healthy), Zhivo povorachivajsja! ‘Get moving! Expected open-closed aspect contrasts appear in exhortations, prohibitions and permissions:

Rosenberg (spokojno): Kazhetsja, pridetsja vas povesit’. Marfa Petrovna. Veshaj! ‘R.: It seems we shall have to hang (pf) you. M.P.: Go on and hang (ipf) me then’!

Skazhite emu / ne govorite emu. ‘Tell (pf) him / don’t tell him (ipf).’

Delajte kak xotite, mne vse ravno. ‘Do (ipf) as you please, I don’t care.’

An imperfective imperative is more polite, less demanding than a perfective one (Forsyth 1970:§7.3.6) in

Zakryvajte i poexali. ‘Please close (ipf imp) the doors and we’ll be on our way.’

Inna, znakom’sja s moimi druzjami. ‘Inna, meet (ipf imp) my friends.’

The politeness effect is reversed when a request is repeated:

Sjad’, Il’ka! Radi Boga, sjad’! Nu da sadis’ zhe! ‘Sit (pf imp) down, Ilka! For goodness’ sake, sit (pf imp) down! Will you just sit (ipf imp) down! ‘Vyvernite karmany! Nu zhivo! Chto ja vam govorju? Vyvorachivajte! Turn out (pf imp) your pockets! Come on, hurry up! Do you hear me? Turn (pf imp) them out!’

It is polite to ask someone to be complying soon (rather than do it now) if this leaves the timing of the completion to the addressee, but impatient and impolite to demand them to be complying now, meaning that they ought to be at it already. Note the particle zhe ‘just’, related to uze ‘already’. As usual, politeness is not in the words, but the actions, attitudes and consequences accompanying them.
Cycles

Another peculiar use of the Russian imperfective (though by no means peculiar to Russian only) is its use for 'two-way action' (Johanson 1998:§10.4.4), i.e. cycles (changes followed by the opposite change, Smith 1991:310ff). This is the case where in (~ss) instantiates to ~ss-vs.

Da ona vrode ushla kuda-to. - Uxodila. A potom vernulas’. ‘It seems that she went (pf) somewhere. - She did go (ipf). But then she came back (pf).’

On eshche ne prosnulsja? Net, on prosypalsja a potom snova zasnul. - ‘Hasn’t he woken up (pf) yet? No, he awoke (ipf), but then he fell asleep (pf) again.

The cyclic reading is characteristic for Russian motion verbs. Motion verbs are traditionally given special treatment in Russian grammar. Besides a perfective-imperfective distinction, it is customary to distinguish an opposition between determinate (one-way, det) and indeterminate (undirected, indet) movement. There are thus up to four variants of a given motion verb: iditi/xodit/priidit/prixodit ‘go/walk/come/come and go’

Actually, the contrasts are one and the same aspect distinction applying twice. The determinate/indeterminate contrast between the unprefixed forms iditi/xodit describe a contrast between a displacement, which is a process accomplishment, and iteration of displacements (undirected movement, including back-and-forth movement). For example, Russian iditi(pf det) ‘go (on foot)’ denotes change of place go, i.e. going from one place x to another y (hence, movement in one general direction). As a process accomplishment, it can be open or closed, depending on whether the source and goal are fixed or not. Its imperfective xodit ‘walk’ denotes an iteration go of displacements, possibly changing or reversing direction. The perfective derivative priidit(pf det) ‘come, arrive’ is an achievement ~here,here, which is why its imperfective pairprixodit (ipf det) only has iterative uses, including the cyclic sense of ‘visit’ ~here.here.~here (Lindstedt 1985:156).

In the following pair of examples, the aspect contrast appears to play on the distinction between one-way and two-way movement: each example was brought up once, while the child was brought to the doctor and back several times.

V doklade on trizhdy privel primery iz Zadonschchiny. ‘In the lecture he gave examples from Zadonshchina three times.’

On trizhdy privodil svoego rebenka na priem k vrachu. ‘He took his child to the doctor three times.’

A case involving a transitive verb is otkryt/otkryvat' okno ‘open a window (pf: completely/ipf: a little or for a while). The same contrast is found betweenFinnish total and partial object (Leinonen 1982). lainata kirja ‘give/take a book (nom) on loan’ vs. lainata kirjaa loan/borrow a book (ptv) for a while’, avata ikkuna(a) ‘open a window (ptv:a little/for a while), nostaa hattu(a) ‘lift a hat (ptv: a little/for a moment as in greeting)’. As the English glosses show, the common feature of transient and partial uses of the imperfective is the absence of a final state of the change. After the event the book is not out on loan, the window is not open, the hat is not up. Note that the English open a window for a while is process/result ambiguous in very the same way as its Russian or Finnish translations are: either the process of opening or its result (window being open) is limited.

This confirms the suggestion in Leinonen (1982) that the transient use of the imperfective can be subsumed under iteration. Our formalism makes this obvious, for a cycle is a special case of the iteration of a change.

Iteration

The formalism also covers the use of the imperfective to denote iterated or plural distributive events: otkryvat’ vse okna ‘open all the windows once one by one’. This represents the special case e’ where pro is reduced to identity. Because there is nothing specifically irresultative about this reading, it does not translate into Finnish partial object avata kaikkia ikkunoita which can only mean ‘open/be opening all the windows a little/for a while/ repeatedly’. Example:

Mne eto nadoelo: tri raza podogrevala obed. ‘I’m fed up with this. I’ve reheated (ipf) the dinner three times.’

Znal, chto detej u nee bylo shestero i odin za drugim umirali vse ochen’ rano… ‘He knew that she had had six children, and they had all died (ipf) young, one after another.’

Perfective aspect umerli would treat the deaths as one event (Leinonen 1982:144 referring to Forsyth 1970).

Marked iterative forms are used for habitual generics: On byval v Moskve ‘he was generally, on and off in Moscow’ does not entail On byl v Moskve ‘he was in Moscow’. The adverbial use of an indeclinable iterative past byvalo ‘it used to be’ in Byvalo, on otkroet vam samyj slozhnyj zamok ‘Time was, he will (pf pres) open the most complicated lock for you’ resembles Navajo temporal shifters (quod vide, Smith 1991:319). Sichyval ‘used to sit’ has a colloquial past habitual iterative suffix.

Existential perfect

The so-called general factual (konstatacija fakty deistvija), or existential perfect use of past imperfective already mentioned above involves an ‘at least once’ reading of unmarked iteration e’<now. It implies that the event has taken
place at least once (perhaps just once) in the past. As expected, adverbials like raz, odnazhdy, ni razu 'once, ever' go with this sense, as well as evidential hinges (opredelennno, mne kazhet'sja 'certainly, apparently'):

\textit{Odnazhdy} on uzhe poluchal vygovor za opozdanie. ‘He has already received (ipf) a reprimand once for being late.’
Gde zhe moj bilet? Ja ved’ opredellenno \textit{bral} bilet. ‘Where is my ticket? I certainly did take (ipf) the ticket.’
Ruchki net, no mne kazhet'sja, chto ja \textit{klat} ee tuda. ‘The pen is not here, but I think I (have) put (ipf) it here.

The imperfective allows the event reduce to a cycle \textit{~s.s.-s?}, so the persistence of the result is uncertain, or irrelevant, in contrast to the perfective:

Ja uzhe \textit{zapolnjal} anketu—zachem zhe eshche raz? ‘I have already filled out (ipf) a form - why should I do it again?’
Ja uzhe \textit{zapolnil} anketu. Ona nakhoditsja u dezhurnogo. ‘I already filled out (pf) the form. The receptionist has it.’
Ty segodnja \textit{pokupal} gazetu? ‘Have you already bought a newspaper today? (I would like to come along.)
Ty segodnja \textit{kupil} gazetu? ‘Did you buy a newspaper today? (Show it to me.)

The Russian past imperfective avoids definite adverbials (Rassudova 1967:24, quoted in Leinonen 1982:224). The only temporal adverbial allowed in the next example is unspecific kogda-to (once), anything more definite would demand the perfective. Leinonen also notes that the imperfective is incompatible with a singular count object:

V etom meste ja \textit{kogda-to nakhodil} malinu/belyje griby/*belyj grib. ‘Here I have once found raspberries/mushrooms/*a mushroom.’

In the next example, ‘at eight o’clock’ goes with the imperfective only as an afterthought, not in construction with the tense.

Ja uzhe \textit{davalldal} ego vam, v yem chosov. ‘I have already given (ipf) /gave (pf) it to you, at eight o’clock.’
Etoch chelevek vam znakov? Da, ja \textit{odnazhdy vstrechal} ego/\textit{ja} vstretil ego v pozaproschom godu v nebol’shoj derevushke na beregu morja. ‘Do you know this man? Yes, I have once met (ipf) him/I met (pf) him year before last in a small village on the coast.’
Moja kartochka v poliklinike dolzhna byt’. Ja \textit{uzhe} vygovor za opozdanie. ‘He has already received (ipf) a reprimand once for being late.’

Loose past adverbials are possible, the last example above shows (also from Leinonen 1982). This suggests that the reason for incompatibility of Russian imperfective past with definite past adverbials here is different from the incompatibility of English present perfect with proper past adverbials. Unlike the former, it does not depend on the near-remote distinction, but on the tightness of the adverbial. Loose (indefinite) past adverbials allow the existential perfect reading, but tight (definite, punctual) ones turn the imperfective into a progressive. The event in imperfective aspect fits loosely (with uncertainty about the precise location) within a year, but wraps around a definite moment (e.g. \textit{togda ‘then’}), becoming progressive. Portuguese would use Perfecto in the former case and Imperfeito in the latter.

**Russian perfective**

A perfective past in Russian either tells that an event has been completed and its result obtains now (result perfect) or that it occurred at the time of a narrative and its results held then. This is vagueness rather than ambiguity, because obviously a past time either extends to now or it does not. Russian, like Portuguese, does not mark the difference, languages with a perfect do.

The contrast in resultativity between the perfective and imperfective past has been compared by Russian scholars with the contrast between Greek perfect and aorist, as concerns the presence or absence of consequences at a later point of reference. Typical examples of present result perfect are

\begin{itemize}
\item On eshche ne prosnalsja (pf pret)? Has he not woken up yet (Is he still asleep)?
\item Vy poterjal kl’uch? ‘Have you lost (pf pret) your key (is it lost)?’
\item Arestovannyx vypustili (pf pret) a polica stradaet. ‘The people that were arrested have been let loose (are loose), and the police are suffering (ipf pres).
\item S tex por ja ugomonilsja (pf pref), esli ne poumnel (pf pret). ‘Since then I have settled down, though I haven’t grown any wiser.’
\item Kak pochti vse nashi kladbishcha, ono javljajet vid pechal’nyj: okruzhavshie ego kanavy…; serye dervjannye kresty ponikli i gnjut pod svoimi krysami… ‘Like almost all our graveyards it presents (ipf pres) a melancholy appearance; the ditches which mark its borders have long since been overgrown (pf pret); the grey wooden crosses have fallen askew (pf pret)and are rotting (ipf pres) under their roofs…’
\end{itemize}
The result implicature is cancellable, after all the perfective preterit is also the primary narrative form in Russian. On the other hand, as always, the perfective does not guarantee narrative progression.

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On voshel, otkryl okno, i vyshel. ‘He entered (pf), opened (pf) the window, and went out (pf).’
On odnovremenno napisal pis’mo i proslushal kassetu. ‘He simultaneously wrote (pf) a letter and listened through (pf) the cassette.’
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Not surprisingly, _snova_ ‘again’ favors perfective aspect:

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Valentina _chuvstvovala_, chto ego vzgljad uskol’zajet ot nee. ‘Valentina felt (ipf: was feeling) that his gaze was avoiding her.’
Valentina _snova pochuvstvovala_ sebja schastlivoj. ‘Valentina felt (pf: began to feel) happy again.’
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### Russian tenses

Russian only has one a two-way distinction between past and nonpast. In conformity with universal defaults, the nonpast tense of the imperfective aspect has present reference, while the perfective does duty for future. Imperfective future is expressed with future auxiliary _budet_ ‘become’ or with adverbials: zavtra my _uezhdajem_ ‘We are leaving (ipf) tomorrow’.

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On _brosit_ kamni. ‘He will throw (pf) the/some stones.’
On _brosaet_ kamni. ‘He is throwing (ipf) stones.’
On _budet_ _brosat’_ kamni. ‘He will be throwing stones.
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The Russian preterit suffix _l_ is morphologically a past participle inflected for gender and number but not person. Smith (1991:327) maintains that it is a relative tense indicating anteriority either to speech time or to reference time. The simplest proposal consistent with these observations is that the Russian preterit is a (free or bound) simple past esnow. With help from aspects, it covers everything better endowed languages do with their various past tenses. (Well, discounting aspect, how many languages do have more than one indexical past tense?) Unmarked for deixis, the Russian preterit can have either free (present or past) or bound (past, present or future) reference time.

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Vot on _prishel_. ‘There, he has arrived (pf) (is here).’
Vchera on _prishel_ rano. ‘Yesterday he arrived (pf) early.’
On _uzhe_ _prishel_ togda. ‘He had already arrived (pf) then.
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In the following type of example (Forsyth 1970:191), there is a straightforward present perfect bound to a generic present:

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V Odesse kazhdyj junosha - poka on ne _zenilsja_ - _sochet_ byt' junogoj na okeanskom sudne. ‘In Odessa very young fellow, before he marries (pf pret) (lit. while he has not married), wants (ipf pres) to be a cadet on an ocean-going ship.
Kak to’ko kto-nibud’ iz studentov _postavil_ nepravil’no udarenie, _upotrebil_ ne to slovo, ja _zamechaju_ eto srazu. ‘As soon as one of the students places/has placed (pf pret) the stress incorrectly, or uses/used (pf pret) the wrong word, I notice (ipf pres) it at once.
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### No pluperfect

Russian only has one past tense so it cannot have a sequence of tense rule shifting events anterior to narrative time back in time. How does Russian get by without pluperfect? One part of the answer is that it obeys the quoting rule for tenses embedded in intentional contexts (Forsyth 1970:§4.1.4, Timberlake 1982, Fabricius-Hansen 1986).

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On _skazhal_, chto ljubit/ljubil ee. ‘He said that he loved/had loved (pres/pret) her.’
On _ponjal_, chto v etot moment Petrov _ne slushaet_ (ipf slusalj) ego. ‘He understood (pf pret) that at that moment Petrov was not listening (pres ipf) to him.
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Sejchas ona xlopotala u pechi. Pavlik zamechal, chto ee plechi vzdragivajut ('vzdragivali'). 'Now she was fissing (ipf pret) at the stove. Pavlik noticed (ipf pret) that her shoulders were trembling (pres ipf).' 

Ona podchas porozhitala, chto pri Todsoske u nee otkuda-to braли ('berutsja') ostreye slovca. 'She was occasionally surprised (ipf pret) that around Todsoske sharp words would issue (ipf pret) from her.' 

Inogda zaxedil Sasha. On s vosxishcheniem posmatrival na Natalku, i Serega zamechal, chto ona pri etom opuskala ('opuskaet') glaza. 'Sometimes Sasha dropped in. He looked with rapture at Natalka, and Serega noticed (ipf pret) that at this she would lower (ipf pret) her eyes.'

In the last two examples, a regularity is observed, not an individual event. Formally, the scoping is observe('e') not observe(e). The difference is one between perception and inference, seeing how and seeing that.

Another explanation is of course that Russian is simply vaguer about temporal relations than some other languages. A pluperfect reading is laid on a preterit by understanding the script (Holden 1990:148, Chvany 1990:225). Failure to follow the script is a common source of interference in translations from Russian.

There are also ways to compensate for the lack of pluperfect with other means. The obvious solution is to use absolute or relative time adverbials which explicitly order the events:

Gnetov pozdorovalsja, ona otvetila sderzhanno i vse-taki sovsem inache, chem otvechala ran'she. 'Gnetov greeted her, but she answered (pf pret) in a reserved way, entirely differently than she had been answering (ipf pret) previously'.

A common trick is to use aspectual adverbs uzhe 'already' and vse 'still' which by their definition indicate that an event has started earlier than the reference time.

Poezd uzhe tronulsja, a v vagon vse prygali kazaki. 'The train had already started (pf pret, but Cossacks still kept jumping (ipf pret) into the carriage.).'

Nastupil den' ot'jezda. Samolet uzhe pokinula raion. "The day of departure arrived (pf pret). The plane was leaving (ipf pret) in the evening, but he had been (ipf pret) on edge since early morning, he was not his normal self.'

By our definitions, the first example entails that both the departure took place and the jumping started before the reference time; at the reference time (the time of the second preterit), the train was moving and the jumping went on.

~move.move.move~then A jump~jump~then

The difference is clear in the next two examples, where addition/deletion of uzhe inverts the order of events.

Kogda otgremeli poslednie vystrely, gruppa uzhe pokinula raion. 'When the last shots died down (pf pret), the group had already abandoned (pf pret) the region.'

Kogda tanki dostigli kanala, fashisty vzorvali most. 'When the tanks reached (pf pret) the canal, the Fascists blew up (pf pret) the bridge.' (Timberlake 1982:312-313)

In the following sentences a perfective is coerced to a pluperfect by being coordinated with a state:

Pavel Petrovich … slavilsja smelostiju i lovkostiju … i prochel vsego pjat’, shest’ francuzkix knig. 'Pavel Petrovich had (ipf pret) a reputation for boldness and physical prowess … and had read (pf pret) five or six French books.'

Ja konchil - otvetil ja sosedu. Konchilsja i klass. Naturschik sokshel s jashchikha i odevalsja. 'I’ve finished (pf pret), I said (pf pret) to my neighbour. The class had also finished (pf pret). The model had got down (pf pret) from his box and was dressing (ipf pret)...'

Mal'chik perestal est’ i smotreli na menja s isugom. 'The boy had stopped (pf pret) eating and was looking (ipf pret) at me in fright.'

The event time of an imperfective existential perfect is free from narrative sequence and thus the form can relate an event that happened before the narrative time. According to Leinonen (1982:202ff.), this is the reason for the choice of the imperfective over the perfective in examples like below.

V konchee koncov, napisala by mne. Adres ja tebe ostavljal (ipf). 'After all, you should have written me. I had left (ipf pret) you my address.'
Myshej u menja bylo mnogo, ja slyshal, ezhik ix lovit, i reshil… ‘At my place there were a lot of mice, I had/have heard (ipf pret) that hedgehogs catch them, and so I decided…’

Odnazhdy, kogda ja ezdila v dom otdyxa v nojabre, ja zaxvatvala s soboi lyzhi, no oni mne absoljutno ne prigodilis’. ‘Once when I went (ipf pret) on a trip to a holiday resort in November, I had taken (ipf pret) along a pair of skis, but they were absolutely useless’.

Zvon utix, a za oknom vse tak zhe, kak i sredi nochi, kogda Shukov vstaval (ipf) k parazhe, byla t’ma i t’ma. ‘The ringing stopped, but outside, just as in the middle of the night when Shukov had got up (ipf pret) for the latrine, it was pitch dark

Actually, since there is no sequence of tense rule in Russian, in first person narrative the event time here can be counted back from the time of narration, which places the event time ‘in the background’, i.e. does not relate it to the reference time of the narrative. This is one reason why notions of grounding are in favor with slavicists.

Time adverbials
In English, the perfect only allows extended now adverbials, the simple past must be used with definite past time adverbials. The existential perfect use of the imperfective in Russian was found to be subject to restrictions as well (Leinonen 1982:223ff). This facilitates the choice between existential perfect and past progressive readings of the imperfective. A tight past time adverbial suggests the progressive reading, an extended now adverbial the perfect reading.

On uze chital zapisku? ‘Has he already read the note?’

Kogda ja voshel v komnatu, on chital zapisku. ‘When I entered (pf pret) the room, he was reading (ipf pret) the note.’

Definite versus indefinite time reference similarly helps distinguish between present resultative and past narrative perfectives.

K vam kto-to prishel. ‘Someone has come (pf pret) for you (and is still here).’

Vchera prishel pochtal’on. On posidel, popil s nami chaj, i ushel. ‘The postman came (pf pret) yesterday, He sat (pf) for a while, drank (pf) some tea with us, and left (pf).’

In Russian, the perfective is used with vsegda/nikogda ‘always/never’ in dispositions:, the imperfective in habits (Leinonen 1982:122):

E, vsegda ja chto-nibud’ braknu iskljuchitel’no glupoje. ‘Eh. I always blurt out something extraordinarily stupid.’

Pravda vsegda peretjanet. ‘Truth will always prevail (pf).’

Xorosho vospitannyj chelovek nikogda ne pozvolit (pf) sebe sostarit’sja. ‘A well brought up person never lets herself get old.’

Ja k nochi vsegda dochke rasskazyvala, ona u menja tozhe vot, kak ty, bespokojnaja, a raskkazhesh” ej na son, ona i usnet, krepko tak…’

I always used to tell stories (ipf pret) to my daughter at night, she was restless like you. But you tell (pf pres) her a story before sleep, and she will fall asleep, (pf pres) so soundly…

Zhil, vprochem, on ochen’ ploxo i, nado dumat’ golodal, potomu chto vsegda radoval’sja, esli Vershinin daval emu ryby.

‘But he apparently lived (ipf) very poorly and probably went hungry (ipf), because he was always overjoyed (ipf) if Vershinin gave (ipf) him some fish.

On vsegda najdet/nahodit vyhod. ‘He will always find (pf) a solution (when one is needed); he always finds (ipf) a solution (keeps always finding solutions)’.

As expected, nikogda goes with the imperfective preterit when it means not ever/at all:

‘Heavy thoughts flashed through Petka’s reckless brain: “What? I have to kill (pf) a human being? I have (ipf) never killed (anyone).’

Jul’ka - eto… Ja dazhe ne znaju, kak eto ob’jasnit’… Odnim slovom, ja takoj devushki eshche nikogda ne vstrechal.

‘Jul’ka is … I don’t even know how to explain it… In a word, I have never met (ipf) a girl like her yet.’

Russian durative adverbials as a rule pair up with the imperfective, not perfective.

On vsju molodost’ bojalsja otca. ‘Throughout his youth he feared (ipf) his father.’ (Smith 1991:310)
Ja (*na)pisal pis’mo materi dva chasa. ‘I wrote a letter to my mother for two hours.’
On stojal na uglu s dvux do pjati. ‘He stood (ipf) on the corner from two to five.’
Polgoda zakaz vypolnjali. ‘We spent half a year filling out (ipf) the order.’

This looks like a scope difference between Russian, a lexical aspect language, and grammatical aspect languages like Portuguese, where durative adverbials go with the perfective.

In contrast, and rather like the Portuguese perfective, productive aspectual prefixes po/pro/do ‘temporarily/through/to the end’ are compatible with durative adverbials. po allows an object-like adverbial of time, pro requires one, do takes do ‘until’ adverbials. These prefixes are thus able to scope over the adverbial (Dahl 1984):

On prostojal na uglu celjy chas. ‘He stood (pf) on the corner a full hour through.’
On postojal tam chas. ‘He stood (pf) there for an hour.’ (Dahl 1984:12)
Oni pozhili god na juge ‘They lived (pf) in the south for a year.’
Ona dozhila do vesny. ‘She lived on (pf) until summer.’

Dahl (1985) claims that Russian bystro ‘quickly’ goes with perfective aspect but medlenno ‘slowly’ and dolgo ‘long’ with imperfective aspect. Actually, bystro takes both: imperfective, meaning relative duration, i.e. continuous speed (fast) or discrete pace (lively), and perfective, meaning absolute duration (soon). Medlenno also allows both aspects pf (slowly dress) and slowly (ipf dress). Dolgo ‘long’ goes with imperfective aspect, when the adverb scopes over the aspect (ipf wait) long, but it too allows wide a scope perfective po pf (wait long).

Rogov vzjal shariki i dolgo razgladyval/razgljadel, dazhe ponjuxal.

‘Rogov took (pf) the balls and looked (ipf) at them for a long time, even sniffed (pf) them.’
Grigorij razdevalsja medlenno, vyigryvaja vremja. ‘Grigory undressed (ipf) slowly, playing for time.’ (Forsyth 1970:62)
On vernulsja, medlenno razdelsja i leg. ‘He returned (pf), took off (pf) his clothes slowly and lay (pf) down.

My dolgo (po)jstojali tam. ‘We waited there (pf/ipf) for a long time.’ (Forsyth 1970:63)

The progress adverbs postepенно ‘gradually’ and s kazhdoj sekundoj ‘with each second’ too allows both aspects (Forsyth 1970:63):

Postepenno telo opjat’ priobrelo/priobretalo gibkost’. ‘Gradually his body again acquired/was acquiring its limberness.’

Minonoscy oboshli vokrug transporta. Naprjazhenie narastalo/naroslo s kazhdoj sekundoj. My sobralis” na palube.

‘The mine carriers surrounded (pf) the transport ship. Tension was mounting (ipf) with each second. We gathered (pf) on the deck.’

Obviously, Tension was mounting describes the situation during the dramatic events, so the aspect has to be imperfective (Timberlake 1982:314-315). English and Italian gradually/gradualmente are also aspectually vague, while Italian man mano, according to Bertinetto/Delfitto (1998) is markedly imperfective.

Relative frequency adverbials take imperfective (Mønnesland 1984):

On obychno prixdoli k nam vo vtornik. ‘He usually came (ipf) to us on Tuesdays.’
Ego zhena redko ulybalas’. ‘His wife seldom smiled (ipf).’

Here Russian (together with Polish and Bulgarian) is more "lexical" than Czech, Slovak and Slovene, which use perfective (Cohen 1989). Absolute frequency adverbials allow both aspects.

On pjah’ raz perechital/perechityval eto pis’mo. ‘He (has) read (pf/ipf pf) this letter five times.’
Timberlake (1982:315:316) finds a difference in meaning here, reflected in his examples below.

Vmeste trizhdy proryvalis’/proryvals’ iz okruzenija letom sorok pervogo goda. ‘Together they broke out (ipf/pf) of the siege three times in the summer of ‘41.’
17 oktrjabrja on dvazhdy preodolel/preodoleval Dnepr vplav. ‘On the 17th of October he conquered (pf/impf) Dnepr twice by swimming.’

The distinction is described as one between ‘on various occasions, no less than n times (ipf)’ and ‘n times consecutively (pf)’ (Mathiassen 1990:464). In other words, the aspect choice is unaffected by the adverbial:

On chital Voinu i Mir tri raza ‘he has read War and Peace three times’ ipf read
On prochital pismo tri raza ‘he read through the letter three times (in a row)’ pf read

Bounding adverbials also go with both aspects, but imperfective is iterative (generic), scoping over the adverbial (Dahl 1981). The same applies to point time adverbials (Lindstedt 1985:206).

On napisal pis’mo nachal’stvu za 15 minut. ‘He wrote (pf pret) a letter to the administration in 15 minutes.’
On pishet pis’ma nachal’stvu za 15 minut. ‘He writes (ipf pres) letters to the administration in 15 minutes.’ ipf (write in 15min)

Inogda on vdrug nachinal drozhat’ ot straxa. ‘Sometimes he suddenly began (ipf) to tremble with fear.

Sometimes (ipf (suddenly (pf begin)))

S tex por kak ’since’ takes perfective preterit in the subordinate clause and imperfective present/past, like French or German (Forsyth 1970:235).

No s tex por kak Laevskij reshil, chto on uzhe ne ljubit, on staraetsja/staralsja vo vsem ustupat’ Nadezhde Fedorovne.
‘But ever since Layevsky (had) decided (pf pret) that he no longer loves/loved (ipf pres) her, he has/had sought (ipf pres/preter) to give way to Nadezhda Fedorovna in everything.’

Imperfective and a measure adverb with an optional uzhe ‘already’ does duty for universal perfect in general:

On skazal, chto zhivet/zhil dva goda v Moskve. ‘He said that he had (now) been living (pres) /had (once) lived (pret) two years in Moscow.’
On uzhe dva goda zhivet/zhil v Moskve. ‘He has/had already lived two years in Moscow.’

Russian uses aspect to distinguish between tight and loose readings of do ’before/until’ and poka ’while/until’. Do- in dozhila is a wide scope aspectualiser.

Ona prishla za pjat minut do nachala ‘She arrived (pf) five minutes before the beginning’,
Ona dozhila do vesny ‘She lived (pf) until summer (pf)’

Another contrast observed by Dahl (1984) reveals a difference between lexical and grammatical aspect languages. In the discourse ’What did he do after dinner today? - He wrote letters.’ Russian would use imperfective (without na):

On (na)pisal pis’ma. ‘He wrote (the) letters’.

The perfective prefix na would entail that the event type is lexically closed, which in turn would entail a definite set of letters. Here a grammatical aspect language could use perfective aspect, for the (lexically open) event type is temporally bounded (remote past).

**Nonfinite forms**

Lexical (derivational) in character, Russian aspect carries over to nonfinite forms, including the infinitive (pisat’-napisat’), active/passive imperfective participles (pisajushchij/pisajemyj), active imperfective and perfective gerunds (pisaja/pisav), and a passive perfective participle (prochitannyj).

Smith (1991:333ff) wonders (with Rassudova 1967) why the general factual reading is not carried over to the infinitive. It does not because aspect meaning is compositional, not grammaticised.

Nado skazat’ emu o sobranii. - Ja uzhe govoril. ‘- It is necessary to tell (pf) him about the meeting. - I have already told (ipf) him.
Perfective *skazat’* ‘say’ implies a definite occasion and propositional object, *govorit’* ‘talk’ does not. *Ja uzhe skazal* would mean ‘I already said it then’. *Ja uzhe govoril* means ‘I have already talked (to him, about it).’

Compare also

Ty ne znajesh’, on *zvonil* professoru? - Ne znaju, znaju tol’ko, chto xotel *pozvonit*. ‘- Do you know, did he call (ipf) the professor? - I don’t, I only know he wanted to call (pf) him.’

The questioner wants to know if student has tried to call the professor at all; what the student wanted was to make one definite successful call.

Russian aspectual verbs *nachat’* ‘begin’, *konchat’* ‘end’, *perestat’* ‘stop’, *prodzolzhat’* ‘continue’ take imperfective infinitives. It is usually maintained that *uspet’/udat’sja* ‘manage/succeed’ require a perfective infinitive complement:

V techenie dvux mesjacev mne *udalos* ’/*peretjagivat’ na svoju storonu vsex pedagogov. ‘Over the course of two months I succeeded (pf) in dragging (pf/*ipf) all the teachers over to my side.’

Bol’she poluge *podnimat’* ne *udavalos*. ‘We did not manage (ipf) to plow (pf) more than half a hectare.’

Inogda nam *udavalos* (ipf) *proizvesti*/proizvodit’ sil’nyj nazhim. ‘Occasionally we succeeded (ipf) in exerting (pf) strong pressure.

Kak ty *uspevajes* (ipf) i *rabotat’* (ipf) v institute, i *vesti* (ipf) xozaistvo i *vospityvat’* (ipf) syna? ‘How do you manage at once to work at the institute, do the housekeeping and raise a son?’

As the last example shows, imperfective can also appear to denote successful maintenance of an open event type, as indicated by the formula (ipf manage) (ipf e).

**Classical Greek**

Classical ancient Greek is the traditional showcase of tense and aspect systems for having separate stems for perfective, imperfective and perfect aspects and a three-way distinction in tenses. The Greek system has been depicted as the following cube (Guentcheva 1990):

![Figure 15](image)

The x axis maps past versus nonpast tense, the y axis perfect versus simple phase, and the z axis imperfective versus perfective aspect. The x axis (past tense) is marked by a past prefix *e* (augment) and a distinguished set of person endings, the y axis (perfect) by reduplication, stem vocalism and/or a *k* suffix, and the z axis (aorist, i.e. perfective) by stem vocalism or a *s* suffix.

The morphologically least marked corner is present (for open event types) or aorist (for closed event types). In the latter, the present is marked by iterative reduplication and/or suffixation: *gi-gne*: *skei* ‘is becoming, becomes (pres)’, *e-gen-e-to* ‘became (aor)’, *ge-gon-e* ‘has become, is’ (perf).

The above cube is further dimensioned with voices (active, passive, medium) and modi (indicative, subjunctive, optative). The far corners of the resulting hyperspace are sparsely populated by periphrastic forms or not at all. Future perfect has suffixal forms only for mediopassive voice *pepraxetai* ‘it will have been done’, for active participial periphrasis *pepraxas esomai* ‘I will be one having done it’ is used. The empty back corner diagonally opposite from present would house perfective pluperfect like French passé antérieur *eut fait*, missing from Greek. The morphological symmetry of the cube does not fully match semantics. Though future is morphologically derived from the perfective (aorist) stem, it is aspectually neutral (Kühner 1898:§387). A better semantical fit is obtained from the regular expression

( (opt|sub)?(pf|perf)? ) opt?fut | past.pf?

This enumerates a 3 by 3 matrix of three moods by three aspects, future for two moods, plus two indicative past tenses.
Greek aorist

The Greek indicative aorist is a perfective simple past pf e < now (Armstrong 1981). The aorist stem also forms an infinitive and an active participle, so it is a clear aspect. The aorist turns an open event into an inception or a cycle: ebasileuse 'became king' or 'had a reign' (Kühner 1896:§386.5).

The textbook description of the aorist is the classical case of a past perfective:

Der Aorist bezeichnet die Handlung schlechthin als geschehen und zum Abschlusse gelangt, als momentan in dem Sinne, dass sie für den Redenden sich in einen Moment zusammendrängt und von ihm mit einem Blicke überschaut wird. Der Aorist bildet daher einen Gegensatz einerzeits zum Imperfekt, das die Handlung als eine noch nicht abgeschlossene in ihrem Verlaufe vor Augen führt, anderzeits zum Perfekt und Plusquamperfekt, die die abgeschlossene Handlung als in ihren Wirkungen fortbestehend darstellen. (Kühner 1896:§386)

The aorist stem contrasts with the imperfective stem in expected ways:

Epeithon autous, kai houn epesia, toutous ekho:n eporeouome:n.
'I tried to persuade (ipf) them, and with those who I managed to persuade (pf) I marched on (ipf)'.

'The lived with him (ipf) in good faith … but she moved in (pf) with him while Timokrates was still living.'

The aorist is also used for the English present perfect. It implies nothing about the persistence of the result at present (Kühner 1896:§386.4)

ten ephagon i'epion tei kai aioioisin edo:ka.
'I have eaten (aor) and drunk (aor) from them and given (aor) to the gods’

hounos pater Kephalos epeisthe hypereis tepion te kai aidoioisin edo:ka.
'My father Cephalus was persuaded (aor) by Pericles to come to this country, has lived (aor) here for 30 years and neither we nor he have ever sued (aor) or been/were sued (aor) by anyone.'

The last example above exhibits aorist with ou po;pote ‘not ever’. In Armstrong’s (1981) data the Greek aorist indicative co-occurs with aei ‘always’ only once in a narrative (apud Homer) where it means ‘each time’. Greek aorist does not seem to have a universal perfect use analogous to Portuguese Sempre/nunca foi leal 'He was/has been always/never loyal’ (Kühner 1896:§386.8,Anm.4). Instead, aei ‘always’ goes with imperfective (present and imperfect) forms (Kühner 1899:§382.3):

Aiei gar to paros ge theoi phainontai enargeis. 'For the gods have always in the past appeared (pres) to us clearly.'

Tipte hikaneis he:metro do? Paros ge men outi thameizeis. 'Why have you come (pres) to my house? You have never visited me (pres) before.'

Hikneuo: palai. I have arrived (pres) a long time ago.'

'Choir: The prophet directed you to kill your mother? Orestes: Yes, and so far (lit. hitherto always) I have not blamed/do not blame (pres) my fortune.'

Aiskh. Eumenides 596

Megistas didote ek pantos tou khroneou do:reastoi tous gymnikous niko:sin. 'You have given (pres) the greatest gifts to the winners of sports events since time immemorial (lit. from all the time).

Aorist is used with absolute frequency adverbials (once, twice, every time) and the present stem with relative ones (once a year, often, always) (Armstrong 1981).

The aorist also has a generic use called gnomic aorist

kai bradys euboulos heilen takhyn andra dio:ko:n
'Es ist schon vorgekommen, dass ein langsamer, aber dabei kluger Mann den behandenden Mann auf der Verfolgung eingeholt hat (aor).' Theogn. 329

As Kühner (1896:§386.7) suggests, this looks like a generic use of existential perfect: such things have happened, at least once, frequently, typically, even always. The following passage from Herodotos serves as a connecting link:

En oligarkhie:i..ekthea idia iskhyra fileei engignesthai; autos gar hekastos boulomenos koryphaios einai.. es ekthea megalai alle:i loisi apikneonta:i; ek ho:n stasies engimonta:i, ek de to:n stasio:n phonos, ek de tou phonou apebe: es moumarkhie:n; kai en touto:i diedexe, hoso:i esti touto ariston.
In oligarchy, strong private feuds tend (pres) to arise, as everyone wants to be on top, whence come about (pres) factions, from factions murder, and from murder things have gone over/go over (aor) to monarchy, and this has proved/proves (aor) how far the best the latter is. Herod. Hist. 3.82

Greek imperfect
As in Russian, morphological markedness varies in classical Greek with lexical event type. In productive (newer) conjugations, the imperfective stem is (less) marked and the perfective -aorist is marked: pau-o pau-s-o 'pause (ipf/pf)'. However, for many irregular verbs of closed event type the aorist is clearly the simpler stem (la-m-b-an-ei/e-lab-e 'take'). Suppletion is common as well: horao/eidon 'see'.

Where the imperfective is unmarked, one can look for cases where it allows closure, as in Russian. This has long been presumed to happen in certain change verbs (Kühner 1899:§383.3, Ruiperez 1954:86, Seiler 1993:28, Johanson 1998, Hedin 1998) and attributed by Delbrück to an older state of the language where imperfective was the simple aspect. The phenomenon is rather restricted, it concerns motion (causation) verbs and verba dicendi; the reading appears inceptive: epleon epi te:n Kerkyran 'they set sail (ipf) to Kerkyra', Hoi Ath:naioi elegon toiaude 'The Athenians said (ipf) the following'.

The Greek imperfective stem does duty for a resultative.perfect of certain change verbs (arrive, leave, win, lose, parent, die, save, commit an injustice, defect, see, hear).

Greek perfect
The Greek perfect is morphologically a stem. It has present and past tenses, present perfect and pluperfect. The Greek perfect is resultative ẹλv: it does not only report an event which is completed at present, but it entails that its effects and consequences continue to the present. If this is not the case, the perfective simple past (aorist) is used (Kühner 1896:§385). Here are some typical cases of the persistence of the result of the present perfect.

Hoi amphi Ariaion, hoi prosthen summakhoi ontes, prodedo:kas:in hemas. ‘The Ariaeans, previously on our side, have betrayed (pres perf) us (i.e. are no longer on our side).’

Houtos ton en Me:dois panto:n despote:n heauton pepoe:ken. ‘He has made (pres perf) himself (i.e. is) the master of all of the Medians.’

Eo:s de moi estin e:de: do:dekate:, hot’es Ilion eile:loutha. ‘For me it is already the twelfth day since I came (pres perf) to (i.e. am in) Ilion.’

Emoi gar ho men pate:r katelipenouden, te:n de me:tera teleute:sasan pepaumai(perf) trephon trito n etos touti, paides de moi oupo: eisin hoi me therapeusousin. ‘My father left (aor) me nothing, this is the third year since I stopped (pres perf) supporting (i.e. no longer support) my mother who died (aor), and I have not yet children who would take care of me.’

A neat example contrasting the perfect with the imperfective present stem is

Oude bouleuesthai eti ho:ra, alla bebouleusthai. ‘It is no longer time to be deliberating (pres), but to be done deliberating (perf).’

The following examples contrast the perfect with the aorist. The aorist is used of events which are over, the perfect of those whose results persist.

Tethnasin hoi thanontes ‘those who died (aor ptc) have died (pres perf) (i.e. are dead).’

He polis ektistai/ektisthe: ‘The city has been (pres perf) erected (stands)/was erected (aor)’.

Ho polemos haponten he:mas apestere:ken kai gar penesterous pepoie:ke kai pollous kindynos hypomenein e:nenkase kai pros tous Hell:enas diabibe:ke kai pantas tropous tetalaipo:re:ken. ‘The war has deprived (perf) us of everything and made (perf) us poorer, it made (aor) us suffer many dangers (now over); it has turned us (perf) against the Greeks and made (perf) us suffer many hardships (still present).’

If the event is irresultative, the effect can be one of an experiential (existential) perfect:

Telos eipon. Ake:koate. ‘I came (aor) to the end of my speech. You have heard me (pres perf) (i.e. should know what I have to say).’

Ake:koa men tounoma, mne:moneuo: de ou. ‘I have heard (pres perf) the name (I should know it) but don’t remember it.’

The perfect can also be stative (only the result is implied, no change):

Oresi periestephano:tais pasa Thessaliei. ‘The whole of Thessalia is surrounded (pres perf) by mountains.’
In many cases, the event/result relation is suppletive in other languages: ktaomai/kekte:ka ‘get/have (got)’, eidon/oida ‘see/know’, duo:/dedu:ka ‘dress up/wear’ histe:mi/heste:ka ‘get up/stand’ etc.

**Greek pluperfect**

The Greek pluperfect differs from the pluperfect of many European languages (Latin, English, German) in that it is unambiguously a past resultative, i.e. it entails that the result of an anterior event persists at a past reference time, while pluperfects in the other languages only indicate an event occurred anterior to the reference time.

Kai Peloponnese:ion autose nees exe:konta proepepleukes:an. ‘Sixty Peloponnesian ships had sailed (past perf) over there too (were already there).’

Epoie:sato gar kai pros Amasin summakhie:n proteron he:iper pros Lakedaimonious, metapempsamenos de kai Babylonious (kai gar pros toutous auto epepoie:to summakhie:©. ‘he made (aor) a pact earlier with Amasis, before the one with the Lacedaemonians, also sending for the Babylonians, for he had a pact made (past perf) with them too.

For flashbacks, Greek uses the past tenses of the other aspects (aorist and imperfect). However, they, like the Russian preterit, do not guarantee anteriority, i.e. the place of the event relative to narrative reference time is free (Kühner 1896:§383.4,§385). Anteriority can be guaranteed by the choice of conjunction (epei means ‘after’ or ‘since’) or adverb (prosthen ‘previously’), or it is inferred (Kühner 1896:§386:14).

Apesteilan ta:s hekaton naous, hasper pareskeuazonto. ‘They sent (pf) the hundred ships which they (previously) were preparing/had prepared (impf).

Epei de edeipne:san takhista, parengelthe:ta pyra katasbennynai. ‘When those saw (aor) him, who used to bow/had bowed to him (impf) previously, they bowed to him (aor) even then.

…eide tas ske:nas hou hoi Kilikes ephylaton. ‘[Cyrus] saw (aor) the tents which the Cilicians used to guard/had guarded (impf).

**Greek moods**

Classical greek has two oblique moods, subjunctive and optative. The received view of Greek syntax is that the subjunctive and the optative are moods of preferential clauses (Begehurungssätze). In main clauses, the subjunctive expresses a plan of action, the optative a wish or (often with isos an ‘perhaps under certain conditions’) a weak (conditional but live) possibility.

Ti poiomen? Io:men. Me poie:se:s! ‘What should we do (subj)? Let us go (subj). Don’t do (subj) it!’

Genoio patros eutukhesteros. ‘May you become (opt) luckier than your father.’

Iso:s eipoi an tis ‘Perhaps someone might say (opt)’

In dependent clauses, the oblique moods are bound nonfactual (future or generic) moods against the free factual indicative mood:

Epeide:per panta e:kousate, krinate ‘Since you have heard (ind aor past) everything, decide.’

Epeidan panta akouse:te, krinate ‘Once you have heard (subj aor pres) everything, decide.’

Me anameinomen, heos an polemi:oi genontai, all’io:men, heos eti oiometha euetos an auton kratesai. ‘Let us not wait until the enemies outnumber (subj pf) us, but let us go, while we still think (ind ipf) we can beat them easily.

Mainometha pantes, hopotan orgizometha. ‘We all rave (ind pres) whenever we are (subj ipf) angry’.

Both moods are formed from the three aspect stems. The present subjunctive takes nonpast person endings, the optative past endings. In dependent clauses, optative is the bound mood of past clauses, while subjunctive is used in corresponding nonpast ones. Thus the optative-subjunctive distinction is also a bound past-nonpast contrast.

Greek has a sophisticated set of conditional sentences. A future indicative conditional prefers conjunctive in the protasis:

Ei ekhe:i khre: mata, o:ne:setai biblous. ‘If he has (subj ipf) money, he will buy (ind pf fut) books’

The counterfactual conditional has past indicative forms plus a conditional particle an ‘under certain conditions’ in the consequent. There is no tense opposition, but a perfective-imperfective aspect contrast (Kaegi 1970:§183).
As Lindstedt (1985) shows, there are final preferences are what wishes are.
The aorist and imperfect are perfective and I/he went' (perfective
 future. (Guillaume 19???:§41-50 actually calls (optative) future and subjunctive afferent and efferent futures, respectively.) Detached past future forms are wishful in many languages (conditional preferences are what wishes are made of.) The observation that the optative is weaker or less vivid than the conjunctive also follows: the optative is a weak modality because it is conditional. (Recall the logical connection between possibility and conditionals.)

Adverbials
Aspect determines the meaning of the adverbial heo:s ‘while/until’: open aspect gives while and closed aspect until.
Bulgarian
Bulgarian is another language known for its complex tense and aspect system. As Lindstedt (1985) shows, there are several layers of tense and aspect in it to sort out: lexical event type, one or more layers of derivational aspect, and finite tense/aspect, plus adverbials.
Bulgarian shares with other Slavic languages a system of derivational aspect distinctions (more regular and less suppletive and lexicalised than the Russian). The imperfective is the (name of the) unmarked derivational aspect, contrasting with prefixal and suffixal (-n-) perfectives and suffixal secondary imperfectives (-va-) (Lindstedt 1985:41).
At the same time, Bulgarian resembles Romance languages in having aspectually marked finite tenses: present, imperfect and aorist. The present is an aspectually unmarked nonpast tense, t

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220 As in the classical languages, the first person singular is used as the reference form. Bada means become/stay, i.e. it is <be. Cf ficar in Portuguese.
221 Aspect typology might again help explain such syncretisms (cf. Portuguese).
combinations based on (my reading of) Lindstedt (1985). In addition to aspect composition, I shall discuss Bulgarian bound perfect (the so called evidential mood).

**Imperfective aspect**

In my mind, the apparent complexity of Bulgarian aspect comes from elevating derivational aspect into a grammatical system, instead for the lexical phenomenon it essentially is. As expected, states, activities, and process accomplishments (*pija ‘drink’, *jam ‘eat’, *pisa ‘write’) are imperfective. Some newer verbs, *objadvat ‘have dinner’, *organizirat ‘organize’, *obraszuvat ‘form’ are in practice biaspectual, i.e. the unmarked (imperfective) form has closed as well as open readings (Lindstedt 1985:184). For prefixed perfective verbs, there is a regular suffixal secondary imperfective in va- , e.g. *napisvat ‘write up repeatedly, be writing up’, with progressive or iterative meaning. (Cf. Leskien 1909:§149.B.II.3.)

**Present**

Present tense of open events *ipf* e is the unmarked way to express progressive and generic events. It has a typical range of derived uses as well (historical, reportive, future, Lindstedt 1985:128ff).

- Tja *jade* jabalki. ‘She eats/is eating (pres *ipf*) apples.’
- Kakvoto *reshava, go osastestvajava*. ‘Whatever she decides (pres *ipf*), she carries out.’
- Utre *zaminavam* za cuzbina. ‘Tomorrow I am going (pres *ipf pf*) abroad.’

**Imperfect**

Imperfect of open events *ipf e<now* describe the present in the past as expected.

- Tja *jadeshe* jabalki. ‘She ate/was eating (impf *ipf*) apples.’
- Kogato *izlizax ot stajata, srestnax edin poznat*. ‘When I was leaving (impf *ipf*) the room, I met (aor *pf*) a friend.’

**Aorist**

Aorist of open events *pf ipf e<now* describe irresultative past events. Lindstedt (1985:217) explains that aorist imperfectives report ‘generalized events’, events isolated from their setting, not considered for their results, nor as transitions from a particular state of affairs to another. They have no particular result beyond having happened.

- Dnes uciteljat me *nakazva*. ‘Today the teacher punished (aor *ipf*) me.’
- Kato malak vednaz *padax ot tova darvo*. ‘As a child, I once fell (aor *ipf*) from that tree.’

The event type of the aorist imperfective is a cycle, a temporally bounded open event *pf ipf punish* ‘did some punishing on me’. Aorist process accomplishments appear intransitively; a corresponding aorist perfective requires an object (Guentcheva 1990);

- Jusuf *pisà, barsà, pisà, barsà i v kraja na kraishtata onovo se *zadarzha ...*
  ‘Jusuf wrote (aor *ipf*), erased, wrote, erased, and in the end started (aor *pf*) from the beginning again’
- Jusuf *napisa i izbarsa* njakolko pati *dumata*. ‘Jusuf wrote (aor *pf*) and erased (aor *pf*) the words a few times.’
- Doktor Xaralampi … *igra do kasno na karti …. i spa do deset sutrinta*. Toj se *izlezhava dalgo v krevata, stana* bavno.
  ‘Doktor Xaralampi played (aor *ipf*) cards till late at night and slept (aor *ipf*) till ten o’clock am. He lay in bed (ipf *impf*) for a long time, (and then) got up (aor *pf*) slowly.

Note the durative adverbials like *tri dni* ‘three days’, *dalgo* ‘for a long time’, *do kasno* ‘till late at night’, *do deset sutrinta* ‘until ten am’ that turn open event types into cycles. As expected, Bulgarian *dalgo* agrees for lexical aspect with Russian but for grammatical aspect with the Romance languages.

  ‘Marin had lost (pluperf) three goats. He was (impf) not a man who could bear a loss, and he did not give in (aor *ipf*) till he found (aor *pf*) them. For three days he *lost himself* (aor *ipf*) in the mountains. He *climbed* (aor *ipf*) steep slopes and *descended* (aor *ipf*) into the darkest spots. Finally he found (aor *pf*) the three goats which he had lost (pluperf).
I ne se varna. Xodi toj ot grad v grad, dalgo nosi ciraskata prstilka, spa po golite daski na rabotilnicite, gladava i naj-posle se izmakna s profesija v zivota.

‘And he did not return (aor pf). He walked (aor ipf) from town to town, wore (aor ipf) an apprentice’s apron for a long time, slept (aor ipf) on the bare boards of workshops, starved (aor ipf), and finally reappeared (aor pf) with a profession in the world.

A description summarised by an imperfective aorist (note the durative adverbial) can be expanded on in the imperfect:

Toj xodi cjal den. Slizashe v dalboki dolove, varveshe pod klonite na stari buki i stari dabove… ‘He walked (aor ipf) the whole day. He kept descending (ipf impf) into deep valleys, walked (impf ipf) under the branches of old beeches and old oaks.’

Imperfect aorist is an existential past tense rather like Russian imperfective preterit (Bertinetto/Delfitto 1998). Imperfective present perfect can also appear here. The English translations probably convey the difference (such as it is):

Ne blagodarja. Veche pix/sam pil. ‘No thanks, I already drank it once (aor ipf) /have drunk it (pres perf ipf).’

Predi vreme reshavax sam ja reshaval... ‘I solved it once (aor/ipf)/ have solved it (pres perfect ipf) before.’

Imperfective aorist can thus serve, like Russian imperfective preterit, for unloaded questions. In the following example, an imperfective question ‘did you see him afterwards?’ is first just assented to in the same form ‘I have seen him’ and then further specified a perfective ‘I saw him last night’. The tight definite past time adverbial calls forth a closed event type (as it did in Russian).

Vizda li se s nego sled onaja nost? Vizdax go. Snosti go vidjax tam. ‘Have you seen/did you see him (at all, aor ipf) after that night? I did (aor ipf). I saw (aor pf) him there last night.’

**Perfect**

An existential perfect question is in Bulgarian the perfect of an imperfective verb. A perfective would imply resultativity of some sort: Note that *ever*/*at*/*once* could not be added to the English translation of the perfective variant without changing the implicatures (with*ever*, the implicature is inverted, the same as *never*).

Posestvala li si Avstralija? Have you ever been to Australia?

Posetila li si Avstralija, ce mozes da govoris taka? Have you been to Australia when you talk like that?

Vizdali li ste tozi film? ‘Have you seen this movie?’

Koj e pisal tova pismo? ‘Who has written this letter?’

Perfects of imperfectives allow transient or reversed event readings Koj e otrvarjal cantata mi? ‘Who has been opening (perf ipf) my bag?’ or Vednaz v Stipone doxozda Petko Karavelov. ‘Petko Karavelov once visited (lit. arrived in, aor ipf) Stipone.’

Another use of the Bulgarian perfect imperfective familiar from Russian is the imperfective of manner:

Zatvornikat e napisal dva lozunga nad vrata na kiljata. Pisal e (impf perf) s ostro kamace. ‘The prisoner has written (perf pf) two slogans above the door of the cell. He (apparently) wrote (perf ipf) them with a small sharp stone.’

This type of explicative manner sentence can be paraphrased *He used a small stone to write them*, i.e. the sentence describes the process, not the result.

The perfect of an open event type can be used to denote an extended now. As in English, an existential reading is always available too (Guentcheva 1990:166).

Zhivjala sam 25 godini v Sofija. ‘I’ve lived (perf ipf) 25 years in Sofia (now/once).’

Radvajte se, ljude! Pet veka sme plakali. ‘Rejoice, people! For five centuries we have wept (perf ipf).’

Otdavna ne sam vi vizdala. ‘I haven’t seen you (perf ipf) for a long time.’

Pomolval sam go ne vednazh za tova. ‘I have asked him (perf ipf) that not once (but many times).’

**Perfective aspect**

Bounding prefixes produce closed event types in Bulgarian, adding more or less lexical content in much the same way as in Russian. Aspectual prefix *po* produces cycles as in Russian:

*Posedjaja malko, poprikazvaja, posmjaja se i si otidoxa*. ‘They sat (aor pf) for a while, talked (aor pf) and laughed (aor pf), and went (aor pf) away.’
**Aorist**

Aorists of closed event types pf e <now> are used for foreground events in narratives. Aorists take part in narrative progression.

…vljasza o v stajata si, poglednaxa se, pritinsotaxa se i se celunaxa dalgo i nenasitno. ‘They went (aor pf) into their room, looked at (aor pf) each other, pressed themselves (aor pf) against each other, and kissed (aor ipf) long and avidly.’

Like the French Passé simple, the aorist dojdè ‘went’ is incompatible with oste ne ‘not yet (still not)’, which indicates that aorist remains outside the scope of negation: ne dojdè means ‘there was an occasion where she did not come’, pf(¬come)<now>.

Tja oshte ne doshlat*dojdè. ‘She hasn’t come (perf)/*still did not come (aor) yet.’

Chakaj, chakaj oshte ne sam svarshilt*svarshix, pak I ima kakvo da kazhes ti, sichko e jasno. ‘Wait, wait, I haven’t yet finished yet (perf) /*still did not finish (aor), and you already have something to say, obviously.’

Ne bjox oshte zatvoril oci, kogato me izvika pri komandira. ‘I had not yet closed (plpf perf) my eyes when they called (aor) me to the commander.’

Like French passé composé or Portuguese perfeito, the Bulgarian aorist covers uses of a perfective present perfect:

Njama gi - kaza toj. Noshtes otidoxa v grada. ‘They are not here, he said. They went/have gone (aor) to town tonight.’

Ax, Bojcho, njakoj te predade, izvika tja nespokojno, kogato razkazat dojde no napadenieto na Ognjanov v Altanovskoto xanche ot turcite. ‘Ah, Bojtcho, someone (has) betrayed (aor pf) you! she cried (aor pf) anxiously, when the story came to (aor pf) his pursuit to the inn at Altanovo by the Turks.

The aorist also appears with nikoga ‘never’ for negative existential perfect (‘from oldest times’, Friedman 1986:172). Cf Lindstedt (1985:107)

Az nikoga ne dirix bogatstvo. ‘I never sought (aor pf) wealth’.

Rjadko go chux da pee. ‘I have rarely heard (aor pf) him sing.’

Ni vednazh ne dojde da me vidi. ‘He has not come (aor pf) to see me one single time.’

**Perfect**

In the following examples, present perfect pf e<now> and aorist pf e´<now> contrast reference to a proper past event to existential quantification over an extended now, as one would expect from their difference in focus.

Vsicki, koito vzexa/sa vzeli cuzda sobstvenost, ste bad nakazani. ‘All those who took (aor pf)/have taken (perf pf) somebody else’s property will be punished.

Ne procesox/sam cel tvojata statija. ‘I did not read (aor pf)/have not read (perf ipf) your article (then/yet).’

In the context of periodic events, present perfect and aorist of perfective verbs can come very close, as there is an expected time for the past event (Lindstedt 1985:105, Guentcheva 1990:91). We noted the same with Russian earlier, and it is equally true for English.

Casat e vece dva. Objadvli li ste / objadvaxte li? ‘It is already two o’clock. Have you had lunch/did you have lunch (yet)?

Sjadaj da objadvash. - Ne blagodarja, objadvax. - Zashto se stesnjavash? Svoi xora sme. - Ne, ne se stesnjavam, no sam objadjal.

‘Sit down and have some lunch. - No thank, I had (aor pf) lunch. - Why be shy? We’re at home. - No, I am not shy, but I have had (perf pf) lunch.

This can be expected, if the perfect stands for pf lunch<now> and the aorist for pf lunch´<now>. The difference is that the perfect is about now while the aorist is about the past (Lindstedt 1985:100). This is clearer in negative sentences, where the reference to a specific occasion remains unaffected by the negation. The aspectual adverb yet can also change reference with the tense (by now/by then). Like in Russian or English, a perfect can deny the existential presupposition of an aorist:

A do Plovdiv xodi li? -Ne sam. Che kakvo da pravja v Plovdiv? - But did you go (aor pf) to Plovdiv? - No I haven’t (perf). What would I go to Plovdiv for?

How come 25 for each, Father Tonju, Dobra bleated, didn’t you say (aor pf) thirty? - Have I said that (perf pf)! frowned Jurtalana. - I haven’t said (perf pf) anything.


‘Did (aor pf) you solve your problems (then)? No, I didn’t (aor pf). I haven’t solved (ipf perf) them (yet).’

Chuxte li vaprosa? - Ne, nisto ne sam chvala.

‘Did you hear (aor pf) the question? - No, I haven’t heard (ipf perf) anything.’

The following passage (Guentcheva 1990:216) exemplifies aspectual competition between aorist and perfect. The first form was in the original, but the second form is a live option too. To the extent there is a difference, it revolves around what the sentences are about (past events or present state of the subject). Note the concomitants: for 80 years with the aorist, already with the perfect.


‘I am not for paradise, poor old me. The paradise is for the great, for the rich. With these rags and callous hands, who will let me in there! For 80 years, I (have) toiled and suffered (aor/perf ipf) like a dog, will I see paradise now? In truth I have tried (perf/aor ipf) to live according to God’s rules, but who cares. Will God care about people like me? We have been written (perf/aor pf) in Devil’s registry already when we were born (perf/aor pf).

Present perfect imperfective can denote a cycle of an event later undone by its opposite, as in Russian (Johanson 1998:§10.2.2.1.3):

Koj e otvarjal chanta mi? ‘Who has been opening (pres perf ipf) my purse?’

Present

Present tense pf e<now of perfective verbs produces predictions and generic, reportive, or historical present discourse.

Izkopavam dupka, za da posadja tova dravche. ‘I’m digging (pres pf) a hole to plant this tree.’
Izpushvam cigarata I vilizam. ‘I’ll finish (pres pf) the cigarette and come in’.
Ivan izpushva cigarata si mnogo parzo. ‘Ivan finishes (pres pf) his cigarette very fast.’
Ivan izpushva vseki den po edin paket cigari. ‘Ivan finishes (pres pf) a pack of cigarettes every day.’
Kakvoto reshi, go osastestvajava. ‘Whatever she decides (pres pf), she carries out.’
A pak az ziveja, taka da se kaze, s vsiciki tezi sabitija. Sabudja se nostem, a v glavata mi vse tova … Zapalja cigara, podpra se na vzglavnicata i prodalzhavam da si mislija.
‘But I live (pres ipf), in a way, with all these events. I wake (pres pf) in the night, and it is still all in my head … I light (pres pf) a cigarette, lean (pres pf) on the pillow, and I keep on thinking (pres ipf).
Toj namaljava krachkite si, spira se pred edna vitrina, oglesxda se vnimatelno, pokolebava se malko i sled tova preminava na drugija trotoar.
‘He slows down (pres pf) his pace, stops (pres pf) in front of a shop window, looks (pres pf) carefully around, hesitates (pres pf) for a moment and then crosses over (pres pf) to the other side of the street.’

Imperfect

The imperfect of a perfective verb ipf pf e<now can condition another closed event in an iterated or generic conditional or temporal clause, which again shows that grammatical aspect scopes over Aktionsart (Lindstedt 1985:191). Aorist would be ungrammatical here. If the subordinate clause event is open and simultaneous with the main event, an imperfective verb is used. This form is also used as a bound past future.

Sled kato procetese sutrin molitvata, trazvena za seloto. ‘Always when she had said (impf pf) morning prayers she would leave (impf pf) for the village.’
Vseki pat, kogato izlezxesme na poljana, vizdaxme napred i vdjasno plocite ot pokrivite na parvoto selo i vseki pat te idexa po-bliizko.
‘Every time when we came out (pf impf) on a meadow, we saw (ipf impf) slates of the roofs of the first village ahead and on the right, and every time they were drawing (ipf impf) nearer.’
Kakvoto resheses, go osastestvajasve. ‘Whatever she decided (impf pf) she carried out (impf pf).’
**Pluperfect**

Pluperfect is formed from an imperfect auxiliary and the aorist participle. Adverbials can modify the reference time or event time.

*A bjax doshal oshte v 7 chasa. ‘I had already arrived (impf perf aor pf) at 7 o’clock.’*

Batju mu Jurdan i negovijat sin Kiro, kojto beshe doshal snosti v otpusk, preglezdaxa zatvarkata nasred dvora. ‘His elder brother Jurdan and Jurdan’s son Kiro, who had come (impf perf aor pf) on leave the previous night, were examining the harvester in the middle of the yard.’

Instead of pluperfect, Bulgarian can put background events in simple past tenses, aorist in

*Na drugija den Lila oitde na rabota izmacena ot samnenijata, v koito ja xvarli razgovorat s Maks. ‘The following day Lila went to work tormented by the doubts which the conversation with Max threw/had thrown (aor) her in.***

Dvete snaxi mesixa xljaba i sega palexa furnata. ‘The two daughter-in-laws (had) kneaded (aor) the dough and were now heating (ipf) the oven.***

imperfect in

*Momiceto, koeto xodeshe na sresti pri paraklisa, se be prevarnalo neseto v prijetelka na zenen max. ‘The girl who had come/used to come (impf ipf) to meetings at the chapel had imperceptibly changed (impf perf aor) into a married man’s mistress.’*

Toj si pijina oshte njakolko pati ot iseto v disagite, i negovata kalugerska dusha be se osvobodila ot ceranoto raso, koeto taj dalgo ja pokrivase. ‘He drank (aor ipf) some more times from the bottle in the bag, and his monk soul got liberated (impf perf pf) now from the black kassock that used to cover/had covered (impf pf) it so long.’

and both in

*Za vtori pat fizdashe goljamoto vlecugo. Parvija pat go zarna mimoxodom, beshe oshte savsem malko taralezce. ‘It was for the second time that he now saw (impf) the big reptile. The first time he (had) spotted (aor) it in passing, he was/had been (impf) still a tiny youngling.***

For sequence of tense in Bulgarian (Lindstedt 1985:32,87) compare section on sequence of tenses above and section of Bulgarian reported tenses below.

**Future**

Future is formed in Bulgarian using the auxiliary shte da, now becoming a particle (according to Lindstedt 1985:255, originally ‘will’). Simple future is shte (da) xodi ‘he will go’, future perfect is predictably shte (da) e xodil ‘he will have gone’.

There is further a free past future shteshe da xodi ‘he would go’, a free past future perfect shteshe da e xodil ‘he would have gone’ plus reported ones shtjal da xodi ‘he reportedly would go’ and shtjal da e xodil. ‘he reportedly would have gone’, exemplified by

*Koj mozheshe da predpolozi, ce skormnata takacka Valja Tereskova samo sled njakolko godini shteshe da e izvarsila naj-golemija podvig i shteshe da e zavladjala sarcata na vsicki. ‘Who could have guessed that, after only a few years, the modest weaver Valja Tereskova would have performed (impf fut aor perf) the greatest feat and would have conquered (impf fut aor perf pf) everybody’s heart.’*

*ce kato me podxvana magazinerat: koga mi bil vzeman povece pari, da izlizam vednagi i da ne xodja povece pri nego, ce shtal da me izvaral, ama ne bilo zakanno. ‘This is how the storekeeper came (aor) at me: when had he taken (perf perf impf) me extra money; I was to go (pres pf) out at once and not get (pres) back, that he would have thrown (perf fut aor perf pf) me out, but it wasn’t (perf) legal.’*

**Reported tenses**

Bulgarian (Lindstedt 1985:260ff) is reputed to have a separate series of reported tenses used for second hand reports. The reported forms are taken to constitute an evidential mood of “indirect narration”. Bulgarian reported tenses,

**222** My analysis differs here from Lindstedt (1985:89ff) who construes the aorist and imperfect as relative tenses here.
compared to various evidentials of other languages, are interesting in that the modal sense has developed from a temporal one rather than the other way round. For renarrated speech transposes all tenses into a bound perfect by the following correspondence (Scatton 1984:§6.222):

<table>
<thead>
<tr>
<th></th>
<th>indicative</th>
<th>renarrated (reported)</th>
<th>doubly renarrated (alleged)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>present</strong></td>
<td>chete</td>
<td>reads, is reading</td>
<td>chetjal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>bil chetjal</td>
</tr>
<tr>
<td><strong>imperfect</strong></td>
<td>chetjáshe</td>
<td>was reading</td>
<td></td>
</tr>
<tr>
<td><strong>aorist</strong></td>
<td>chete</td>
<td>read</td>
<td>chel</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>bil chel</td>
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<tr>
<td><strong>perfect</strong></td>
<td>e chel</td>
<td>has read</td>
<td>bil chel</td>
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<tr>
<td><strong>past</strong></td>
<td>be(she) chel</td>
<td>had read</td>
<td></td>
</tr>
<tr>
<td>perfect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>future</strong></td>
<td>shte chete</td>
<td>will read</td>
<td>shtel chete</td>
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<tr>
<td><strong>past</strong></td>
<td>shteshe</td>
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<td><strong>future</strong></td>
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<tr>
<td>perfect</td>
<td>shte e chel</td>
<td>will have read</td>
<td>shtel e chel</td>
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<td><strong>past</strong></td>
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<td>perfect</td>
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<td>chel</td>
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</tbody>
</table>

Table 63

The reported present has the form (sam) xodel, which is an active imperfective perfect participle ‘been walking’, optionally accompanied with the present auxiliary. It can sometimes be translated directly as has been walking, but usually English bound pasts work better. There is also a double perfect form bil xodel ‘had been walking’, implying doubt about the truth of the report. Here bil is the perfect participle of sam ‘be’.

Kazva ce (e) xodel . . . ‘He says/said that is has been/was walking (pres perf impf) and I can believe it’
Kazva ce bil xodel . . . ‘He says that he had been walking (he says he was walking/walked (perf perf aor), but I doubt it’

The reported aorist is identical to the aorist perfect (sam) nastapil, the main difference is that the (third person) auxiliary can be left out in reported contexts. The aorist perfect is perfective and allows proper past adverbials. The so-called dubitative reported aorist (bila eksplodirala) is again morphologically a double perfect and indicates doubt about the veracity of the report.

223 Other languages have similar reportive uses of present and conditional perfect. fi Huhutaan, että hän on/oli/olisi ollut mukana kaappauksessa. ‘The rumor goes that he was/had/would have been in on the coup.’ Although the coup is a definite past event, his participation is uncertain. The reference time of the past perfect is the time of the rumor.
Kazva ce e nastapil taralez --- rece E.S., ce ot tova bila eksplodirala gumata mu i ce za nego tova e goljamo prikljucenie.

“He says/said that he has/had run/ran (pres perf aor) over a hedgehog, E.S. told, “and that his tire had (allegedly) exploded (perf perf aor) because of it, and that this is/was (pres) a great adventure to him.

The reported aorist (basically, the aorist participle alone) is the prime narrative tense of nonwitnessed reports, while the indicative aorist (the finite form) is used for witnessed reports.224 Like the English bound/free tense choice, the choice between free or bound aorist indicates whose authority and what evidence the embedded event is on (Friedman 1986:172):

Toj ne vjarva che tja napravi tova. ‘He does not believe that she did it (aor) (but she did).’

Prochel sam tazi kniga, kaza ti go veche. ‘I have read this book (I claim), I already told you (you heard it).’

Replacing the second simple past with perfect would distort the relation between the two sentences. The addressee is reminded of the previous telling, not informed of it. A minimal pair from Cohen (1989:135):

Basta mi e umrel/Car Simeon umrel v 927 godina. ‘Mon père est mort./Le tsar Simeon est mort en l’an 927’.

According to Lindstedt (1985:90) the perfect is used in the complements of verba dicendi et sentiendi. The indicative aorist is ungrammatical in this environment. It is not possible to say Toj kazva, ce Ivan prochete knigata ‘he says that Ivan read (aor) the book’; the perfect or the reported aorist (e) prochel must be used instead. My interpretation is that Fabricius’ quoting rule is obligatory for de dicto (that) complements in Bulgarian. In de re (wh) complements, both free and reported tenses occur, although reported tenses are favored (Lindstedt 1985:33):

Toj dobre razbra kakvo stava/stavashe naokolo. ‘He understood well what was going on (pres/impf) around him.’

Toj dobre razbra kakvo e/beshe stanalo ‘He understood well what had (perf/pluperf) happened.’

Misleše, si kak predi mesec-dva ot visokite varxove na Sinite kameni…toj vidja, ce dolu o patja idat. ‘He thought how a month or two ago he saw (aor) from the high peaks of Blue Rocks… that there were women coming (pres) along the road below.

In the next example, the difference between quoted present and reported aorist seems to correspond to a straightforward present-past distinction in English:

Dvete babicki… objasnjavava na frenski ezik, ce patuvat za Istanbul, ce sa ot frenskija grad Ruan s procutata katedrala, ce smjatali da zakusjat v Sofija, no njakakvomnogo nastraxnalo životno preprecilo patja im…

‘The two little old ladies explained (aor ipf) in French that they were travelling (ipf pres) to Istanbul, that they were (pres) from the French city Rouen with the famous cathedral, and that they had been thinking (perf ipf) of eating in Sofia, but some kind of a very bristly animal had come (perf pf) in their way.’

We might just say the Bulgarian reported tenses are bound (quoted) present perfects, as the morphology would make them (Friedman 1986:185). An aorist perfect like e stanalo above can be free (bound to speech event) or quoted (bound to the narrated speech event (objasnjavava). The event time is either earlier than the narration time (bound present perfect) or undecided relative to it (free present perfect). The absence of a finite auxiliary in Bulgarian indicates the tense is bound.225 Thus the reported present and perfect place events into the embedded narrative, operating as the relative present and past of the narrated speech event.226

A consequence of this reconstruction is that main clause reported tenses get the look and feel of indirect speech, because in order to bind them, a narrative frame must be reconstructed around them. A Bulgarian main clause bil comes to have the same feel as English is to have been. This analysis thus explicates how bound tenses become an evidential mood: they won’t refer until a propositional attitude context is created around them (Lindstedt 1985:267).

**Time adverbials**

Bulgarian uses imperfective verb morphology with durative adverbials and perfective with bounding ones. Aspctual prefixes po ‘for a while’ and pre ‘for the whole time’ scope over durative adverbs as in Russian (Lindstedt 1985:178). Grammatical aspect scopes over adverbials, so the unmarked aspect is aorist; an imperfect with a bounding adverbial becomes iterative (Lindstedt 1985:205):

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224Lindstedt 1985:266 notes (with tongue in cheek) that in a recent Bulgarian history book, the tense changes from reported to witnessed at the year 1878.

225Participles are a source of bound reportative tenses in the Baltic area too, e.g. Finnish Kerrottiin karhun ammutun ‘The bear was told to have been shot (past part)’ or the Estonian modus obliquus in Kuningas olevat saapunud ‘The king is reported (pres part) to have come (past part)’.

226Friedman (1986) presents data indicating that the ellipsis is not fully regular.
Tja *pja* pesenta tri minuti. ‘She sang (aor ipf) the song for three minutes.’
Tja *izpja* pesen(ta) za tri minuti. ‘She sang (aor pf) the song in three minutes.’
Tja *peeshe* pesen (za) tri minuti. ‘She used to sing (ipf impf) a song for/in three minutes’.
*Cetoxme* knigi ot dva do cetiri chasa. ‘We read (aor ipf) books from two till four o’clock.’
*Cetjoxme* knigi ot dva do cetiri chasa. ‘We would read (ipf impf) books from two till four o’clock.’
*Pospax* dva chasa. ‘I slept (aor pf) for two hours.’
*Prechivjox* v Pestera tri godini. I lived (aor pf) in Pestera for three years.’

*Dalgo* ‘long’ allows both aorist and imperfect, depending on what one means (Lindstedt 1985:204). Aorist is preferred if an answer was expected (within a given time). An imperfect denotes an iteration of long stays.

Rokoj niko ne mu obazdashe/obadi. ‘For a long time, no one (would) answer(ed) (impf pf/aor pf) him.’

By default, relative frequency adverbials take imperfect, absolute ones aorist. The lexical aspect is imperfective (Lindstedt 1985:40). Further assumptions can again change the default assignments. An aorist can imply that the habit is over (Lindstedt 1985:201ff).

Nie se *srestaxme*/*srestnexme* (impf ipf/pf) vseki den. ‘We met every day.’

The contrast perfective/imperfective perfect is exemplified by

(Pro)chel sam tazi kniga tri pati. ‘I have read (perf) that book three times (over).’

The imperfective suggests having read it from time to time before now, the perfective a past chore of reading it three times back to back. Aspect scopes over adverbial, same as in Russian.

Aspect determines the meaning of the adverbial *dokato* ‘while/until’:

Tuk ste *zheeve* Konstantin Trofimov, *dokato* prodalzavhava simposiumat na fizicite. ‘K.T. will live here as long as the physicist symposium continues (ipf)’.

Orelat *xvarci*, *dokato* (ne) izpume poslednija si dax. ‘The eagle flies until it gives out its last breath (pf)’.

Az ste *stooj* na selo, dokato *pribirat/pribaret* rekoltata. ‘I will stay in the country as long as they are harvesting (pres ipf) / until they have harvested (pres pf) the crop.

*Dokato* clauses can have a bound present (Lindstedt 1985:120). According to my lights it corresponds to English *while/until* with a bound past future would. Portuguese uses a bound form (personal infinitive or a finite subjunctive) for the same purpose.

The example

Ostavixe go da lezhi v kolibata si, dokato mu *zazdravejat* ranite. Posle mu *pomognaxa* da prexvarli srbskata granica. ‘They left (aor) him lie in his hut until his wounds *were/would be healed* (pf pres). Then they helped (aor) him to get across the border to Serbia.’

**Finnish**
Smith (1991:93) maintains that Finnish (along with Icelandic) has no grammatical aspect (‘grammaticized viewpoints’). That is a question of definition of terms, but as far expressive means are concerned, the situation is not quite that bleak.

**Finnish object case marking**
In this section, I review the topic of Finnish object case marking discussed in Heinämäki (1983), Tommola (1986) and references therein. Recall the example

Mies *ampui* lehmää/lehmain ‘The man shot at the cow (ptv)/shoot the cow (gen) dead’.
These examples suggest the following transitivity analysis of shooting:

\[
\text{shoot(man,bullet) cause p(bullet,cow) cause r(cow)}
\]

In absence of evidence to the contrary, \( p \) is taken to imply that the bullet flew at (at least in the general direction of) the cow. If \( r \) is a change in the cow, the total object case appears. The default assumption is that the cow dies, but that can be defeated. The first sentence seems to be the only one to guarantee that the bullet hit the cow. Even \( \text{in the ramp} \) in the second sentence does not seem to make sure that the bullet actually hit the cow there.

If \( r \) entails no change in the cow (the cow was just the target of the shooting), the object is in the partitive. In general, a partitive object is used in Finnish where other languages have indirect (oblique) objects with meanings related to the prepositions \( \text{in/at/of/from/to} \). There are interesting connections to diathesis (argument structure and transitivity) and to (ir)resultative aspect here. I shall present a selection of cases below.\(^{227}\)

A large majority of Finnish transitive verbs have a live partitive-accusative aspect distinction where the partitive has imperfective uses and the accusative perfective ones. The interesting cases are those where the regularity breaks down: either the verb has only one object case, or it has both but the distinction does not correspond to the imperfective-perfective division. Sometimes the difference in meaning is wider than just an aspect distinction. Such variations often characterise a whole class of verbs of similar meaning. They thus provide evidence for argument structure. In the following overview, we naturally restrict attention to the existence or absence of case alternation in positive sentences with a singular count object. All verbs have partitive objects which are noncount or occur in the scope of a negation. Also, one and the same case can be correctly classified many ways. There need not be only one reason for the aspectual behavior of a verb. There can be several, sometimes independent, sometimes related by a general principle.

**Partitiva tantum**

In general, when the grammatical object is not the subject of a result of the verb in the argument structure, but has the role of a predicate (has some case other than the nominative, cf. reduced transitivity of Hopper/Thompson 1980, Tommola 1990), it appears in the partitive. Such objects surface in various oblique cases in alternate frames and in other languages. As expected, when a result adverbial can be added where the object has subject position, the accusative can reappear.

\( \text{Seurata, edeltää} \) ‘follow, precede’, \( \text{lähentyä, muistuttaa} \) ‘approach, resemble’ are partitiva tantum. These code states, (abstract) relative locations between objects (be \( \text{before/after, near, like} \)). So are \( \text{puolustaa/vastustaa} \) ‘defend/oppose’, which mean ‘be for/against’.

Pure contact verbs \( \text{koskea, koskettaa} \) ‘touch’ are partitive. Touching means that parts (boundaries) of two objects meet: \( \text{part a} \) \( \text{a} \) \text{part b}. Touching is symmetric, noncausative, and atemporal. Touching verbs are cycles, no result or change in the object is implied. Many examples of movement verbs are also touching verbs (see below).

In the closed event type \( \text{Seurasin hänät autoon} \) ‘I followed her (ptv) into the car’ the object \( \text{her} \) stays in the partitive, because the result is that \( I \) go into the car (my following her does not cause \( \text{her} \) to go anywhere). The affected object stays in the partitive despite the result adverbial. Compare \( \text{autoin hänet autoon} \) ‘I helped her into the car’ where I do get her into the car, and the accusative case appears. In \( \text{Hän auttoi minua kuivaamaan astit} \) ‘He helped me (ptv) dry the dishes (nom)’ the helpee stays in the partitive though the helping event is bounded, it is the dishes which get the nominative. The Russian translation has perfective on both verbs: \( \text{On pomog mne vyteret} \) \( \text{posudu} \) ‘He helped (ptf) me (dat) wash up (pf) the dishes’. (Tommola 1990:359)

The object is an underlying instrument and is partitive in \( \text{käytää, käsitellä, soittaa, pelata, leikkitä} \) ‘use, handle, play’. Again as expected, \( \text{käytin saippuan loppuun} \) ‘I used up the soap’ and \( \text{Vastustaja pelasi pallon maaliin} \) ‘the opponent played the ball into the goal’ get accusative object. Alternate frames: \( \text{pelata peli rantapallollo} \), \( \text{soittaa kappale viululla} \) ‘play a game with a beach ball, play a tune with a violin’.

The object is a goal and is partitive (alternating with illative) in \( \text{osoittaa jotakin/johonkin tähdätä jotakin/johonkin, ampua jotakin/johonkin} \), ‘point, aim, shoot at something’. Related abstract partitiva tantum include \( \text{merkitä, tarkoittaa} \) ‘mean’. Not surprisingly, \( \text{yritytä} \) ‘try’ takes partitive; with a near synonym \( \text{pyrkii} \) ‘strive at something’ taking illative.

Speech act verbs which have the addressee as grammatical object are also partitiva tantum: \( \text{puhutella} \) ‘address’, \( \text{varoittaa} \) ‘warn’, \( \text{uhata} \) ‘threaten’, \( \text{pilkata} \) ‘scoff’, \( \text{syöttää} \) ‘accuse’, \( \text{kiittää} \) ‘thank’. The underlying frame is \( \text{say something to someone} \), i.e. the object is the intended recipient of a message, not the object of a causation. There is no

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\(^{227}\) Regularities of this type have been studied since Apollonius Dyscolus (Luhtala 1997:131)
success entailment: the person addressed, warned, threatened etc. may ignore the message. There are a few such verbs of this type which have recently become biaspctual: *haastatella* 'interview', *kuulastella* 'interrogate', with the sense of 'subject someone to an interview/interrogation'. There is a result too, an interview or a protocol. Alternative frames: esittää/osoittaa puhattelu, varoitus, uhkaisu, pilkka, syytös, kiitos jollekulle 'present/direct an address, warning, etc. to someone'.

Some propositional attitudes are partitiva tantum: pelätää 'dread', varoo 'beware', kaivata 'miss', himoita 'cover', rakastaa 'love', vihata 'hate'. These are irrefractory, intentional activities directed at the object but not reaching it; the object of the sentiment is in not affected. Alternate frames: be afraid of; long for, feel desire, love, hate toward someone.

An associated group are the piget putet paenetit taeted atque miseret verbs of Latin grammar, or emotion causatives: harmittaa, kiussaa 'piget', nolottaa, hävittää 'pudottaa', kaduttaa, surettaa 'paenetit', ikävystyttää, pitkästyttää 'taeted', säälittää, liikuttaa 'miseret'. These have the structure *p cause x feel q* where the grammatical subject *p* is the propositional cause of a state, not the agent of a change. Adding a result allows nominative: *pitkästyttää joku kuoliaisksi* 'bore someone (nom) to death'..

An aspectually interesting case of partitiva tantum are morphological *iteratives* Finnish has a few more or less productive imperfective suffixes (the frequentative -el- more and the durative -i/0 less productive). Examples of partitiva tantum in -el- are tapailla < tavata 'meet (occasionally)', pidätellä < pidättää 'try (to) hold back', tavoitella < tavoittaa 'try to reach', pysäytellä < pysäyttää 'stop (repeatedly)', välittellä/välittää 'try to avoid', muistella <muistaa 'remember'. The derivation is lexically governed, and many (most?) verbs of this form are again biaspctual (e.g. taitutella < taituttaa 'persuade of bend', katsella < katsoa 'look at/gaze/watch'. Katsota has a durative suffix and katsella a frequentative one. If there is a difference, katsota is indeed durative (look continuously, fixedly) and katsella frequentative (look intermittently, shifting gaze). One usually says katsota elokuvaa 'watch a film (nom)' and katsella kuvakirjaa 'look at a picture book (ptv)'. Again, a result adverb licenses nominative: katsella kuvakirja läpi 'look through the picture book (nom)'

Cycles formed by momentaneous suffixes -ais/autta- are irrefractory by default. tünäistä, tyrkitä, potkaista, kopauttaa, vältellä/vältää 'try (repeatedly)', pidätellä <pidättää 'stop (repeatedly)', tavoitella < tavoittaa 'try to reach', pysäytellä < pysäyttää 'stop (repeatedly)', välittellä/välittää 'try to avoid', muistella <muistaa 'remember'. The derivation is lexically governed, and many (most?) verbs of this form are again biaspctual (e.g. taitutella < taituttaa 'persuade of bend', katsella < katsoa 'look at/gaze/watch'. Katsota has a durative suffix and katsella a frequentative one. If there is a difference, katsota is indeed durative (look continuously, fixedly) and katsella frequentative (look intermittently, shifting gaze). One usually says katsota elokuvaa 'watch a film (nom)' and katsella kuvakirjaa 'look at a picture book (ptv)'. Again, a result adverb licenses nominative: katsella kuvakirja läpi 'look through the picture book (nom)'

**Accusativa tantum**

Tommola (1986:106ff) presenting a classification of Finnish event types for object case alternation distinguishes actions from nonactions. For instance, saada, periiä, löytää, keksiä, huomata, havaata, voittaa 'get, inherit, find, spot, notice, win' and their opposites hukata, menettää, kadottaa, unohtaa, hävittää, pudottaa 'lose, forget, drop' are nonactions. In my view, Tommola's nonactions are simple changes or passive causatives (the subject of the sentence is not the subject of the cause: *p(x) cause q(y)*. For instance, if I get something, it just comes to me (an illness) or someone else gives it to me (a gift).

Many accusativa tantum verbs denote simple states, changes, acquisitions or cycles, like tietää 'know', huomata 'notice', todeta 'note', keksiä 'spot', nähä 'see', kuulla 'hear', haistaa 'smell', maistaa 'taste'. Some abstract states and acquisitions belong here too: sisältää 'contain', kattaa 'cover', omistaa 'own', menettää, hukata 'lose', löytyä 'find', saada 'get', painaa 'weigh', maksaa 'cost', vetää 'accommodate'. None of these verbs are causative. Some are causative and biaspctual in another sense: kattaa 'cover', painaa 'weigh down, press', keksiä 'invent'.

Partitive object perception verbs are agentive and conative cycles: partitive kuunnella/kuulla means '(try to) listen', partitive haistella/haistaa '(try to) smell', maistella/maistaa '(try to) taste'. Partitive object nähä 'see' is iterative, vilkaista 'glimpse' a cycle, tuijottaa 'stare' continuous.

Antaa 'give' is the causative of simple change saada 'get'. It is only marginally progressive: ?annoin lahjaa 'I was giving (handing a present)', but forms resultative cycyles: anna kynää hetkeksi 'give me the pen for a moment'.

Speech act verbs whose object is the message practically only accept an accusativa object: sanoa, mainita, todeta, ilmoittaa, hyväksyä 'say, mention, assert, accept'.

**Alternations**

Many (most?) Finnish transitive verbs are biaspctual. Tommola's (1982:117ff) actions in my book are change causatives where the subject causes the change. The cause may or may not involve a process, accordingly as the case may be, a progressive partitive is more or less natural. Tommola lists changes of possession, existence, place (motion), and posture, among other types. Only some of the more interesting instances of alternation will be taken up here.

Maintenance verbs (causatives of permanence verbs) like pitää, kantaa 'hold, keep, carry' allow durative adverbials with both accusative and partitive object. The accusative/partitive object alternation is a live one here too: it can distinguish between an open and a bounded stretch of maintaining, between process (trying) and result (success).
There is a large class of verbs of touching which appear in the partitive if there is no result adverbial: *hipaista ‘graze, skim’, hyväillä, paijata, siltittää ‘stroke, caress’, halata, suudella, kätellä ‘embrace, kiss, shake hands’, puristaa, painaa ‘press, shake (hands)’, taputtaa, koputtaa ‘pat, clap, knock’, lyödä, hakata, potkaista, tuistaa, nipistää ‘hit, beat, kick, pull hair, pinch’, vetää, kiskoaa, työntää, tōnaitā ‘pull, drag, push, shove’, ravistaa, heiluttaa ‘shake, swing’. None of these entail a permanent change in the object. Alternate frames: *tap someone on the shoulder, hit someone in the head, pull, shake at something.*

Most (all?) of them can take a result adverbial, in which case they become biaspectual: *puristaa, taputtaa kokoon ‘press, pat together’, ravistaa, kiskoa irti ‘shake, pry loose’, vetää, työntää kumoon ‘pull, push over’. Many are biaspectual in lexicalised special meanings with selected objects: *siltittää paitsa ‘iron a shirt’, kätellä viers ‘greet the guest’, vetää kello ‘wind up the clock’, lyödä vihollinen ‘beat an enemy’, painaa kirja ‘print a book’, kaataa karhu ‘fell a bear’.

Many verbs of touching are motion causatives at the same time; for touching things with force is one way to put things in motion. Motion causatives like *siirtää, kuljettaa, vetää, työntää, nostaa, laskea, painaa ‘move, transport, pull, push, lift, lower, press’ with a partitive object produce cycles ‘move some way’ or ‘move some way and back’:

Joku on siirtänyt tätä tuolia. ‘Someone has moved this chair.’

The chair has not been moved anywhere in particular, possibly it is back where it was. It is easy to prove that in both cases, the event type is irresuttivative and open. The analogy to Russian movement verbs can be continued:

Kuka on siirtänyt tuolia eteenpäin/ tuolin tähän? ‘Who has moved the chair (acc) forward/(nom) right here?’

Although *eteenpäin 'forward' and tähän ‘here’ may denote precisely the same spot, the difference is that *eteenpäin ‘forward’ is a relative position, ‘here’ is not. Accordingly, the partitive object is fine with *eteenpäin, while with tähän it requires some explanation (perhaps someone has just tried to move the chair there, or the chair is has been moved back).

Compare English *The chair has not moved/budged*. The comparative change *move* allows the chair to have been elsewhere in between as long as it returns to the original position, the momentaneous *budge* does not. *move* is of form *xatp~*xatp, *budge* is a cycle of *move*, or ¬*move.move. ¬move.*

Note the interchangeability between momentaneous actionsart, existential vs. result perfect and perfective vs. imperfective aspect here.

Lainaan tämän kirjan kuukaudeksi. ‘I lend/borrow this book (acc) for a month (tra).’
Lainaan tätä kirjaa kuukauden. ‘I lend/borrow this book (ptv) for a month (acc).’

*Lainata ‘borrow’ with total object is a change, with partial object, it is a cycle. The time adverbial changes accordingly: the transitive adverbial measures the result state, the accusative one the cycle. The difference becomes clear with a further time adverbial: Tänään ‘today’ only fits the former.*

Motion causatives produce spatial metaphors in Finnish too, turning events into simple states. The aspect distinction then turns into a contrast between complete and possibly partial coverage of a region. Examples are *peittää, täyttää, yhdistää, erottaa, valaista, varjostaa, saartaa, ympäröidä ‘cover, fill, connect, separate, illuminate, shadow, surround, circle’.*

Rakennukset ympäröivät talon pihaa/pihan (kokonaan). ‘The buildings surrounded the house (completely).’
Tietystä haitamin pääsyn/estää pääsyn alueelle. ‘The road construction hinders/prevents access (acc/nom) to the area.

A peculiar case is *muuttaa, vaihtaa ‘(ex)change, shift’.*

Laiva muutti suuntaa. ‘The ship changed direction.’
Vaihdoimme sormuksia/sormukset. ‘We exchanged rings (ptv/nom).’
Vaihdoimme mielipiteitä? ‘We exchanged opinions (ptv) / ?our opinions (nom).’

The partitive object *suuntaa, paijata, mielipiteitä* is generic (refers a kind). Interestingly, no article is used in English. Exchanging rings sounds good with both cases, just like loaning books. Nominative object with an exchange of opinions sounds funny, suggesting everyone adopts new opinions, instead of just taking a brief look at them.

Another interesting case is the opposition between positive and comparative change in *lyhentää hame/hametta ‘make the skirt short/shorter’, suurentaa valokuva(a) ‘magnify the photograph (some)’, parantaa potilais/tulosta ‘cure a patient/improve on a result’, vaalista huone/asiain ‘illuminate a room/an issue’. The partitive indicates that the change is only comparative; no particular end point has been reached, and the process might go on: the hemline could be higher, the photograph larger, the result even better, and the issue clearer still. The accusative indicates that some specific bound has been reached: the skirt is short, the photograph is large, the patient is well, and the room is light.
Summing up, what should we say about the Finnish object case alternation? Perhaps this: The nominative is the unmarked case for predicative frames. In relational frames, the nominative/accusative object is marked. It is used if the frame causes a change which has the object of the verb as the subject. Otherwise partitive case appears.

This rule is formulated in terms of diathesis, i.e. resultativity. Does this mean the Finnish alternation is not an aspect (i.e. closedness) distinction? Look at the marginal cases where the two criteria diverge: resultative maintenances are open but they have a nominative object in Finnish; irresultative cycles are closed but they take partitive object. This result agrees with Tommola (1986).

Finnish tenses

Finnish tenses are quite similar to the English ones. One major difference concerns the simple past/perfect borderline, which has been discussed previously. Finnish perfect has wider application than English perfect. Finns tend to overdo English perfect in translation of Finnish into English. Conversely, many English English uses of the simple past go over to the Finnish perfect.

Roughly, the differences are that the English perfect is a near perfect and the English simple past uses descriptive identity criteria, while the Finnish perfect is existential and the simple past obeys acquaintance criteria. The Finnish perfect is historically an active predicative form be+active past participle. It allows definite past adverbials in an evidential sense. Finnish uses the perfect with definite event time adverbials if the event is only inferred, whereas English resorts to the simple past or to an explicit epistemic modal auxiliary.

Lindstedt (1996) notices that the Finnish definite past perfect is not strictly evidential. It more generally assigns a present property to the subject:

(Olen väsynyt koska) olen herännyt tänään aamuna neljältä ‘(I am tired because) I woke up (pres perf) at four this morning’.

Even

(Meitä ei väsyttä koska) olemme menneet eilen nukkumaan kymmeneltä ‘(We are tired because) we went (pres perf) to bed at ten yesterday’

is ok. But compare the following two:

Olen väsynyt koska olen valvonut myöhään eilen illalla. ‘I am tired because I was/have been (perf) up late last night.’

Olen väsynyt koska vauva on valvottanut myöhään eilen illalla. ‘I am tired because the baby has kept me (perf) / kept (pret) me awake late last night.’

The perfect is still more or less ok in the first sentence but not so in the second. The perfect sentence should describe my present condition, not the baby’s.

The following passage exemplifies the contrast between simple past and present perfect in Finnish. It is a newspaper feature of a workday in the brand new traffic control center in Helsinki. The overall tense of the story is reportive present.


‘Normally we give statistical information to the police on average speeds on different sections of road for instance, he says. As a rule we don’t give information about the movements of individual cars, although it would be possible, Helin says referring to the monitoring points on the roadside. There are a handful of cases where we have given (perf) the police information about the movements of a given car. Then it must involve a serious crime, for instance a car chase where lives have been (perf) endangered, he explains. More often the incidences are less serious, sometime a little comical. A couple of weeks ago a special transport got caught (pret) under a bridge because the rig was too high. The traffic got congested (pret) pretty badly while the rig was backing (pret) itself out. Jaywalkers also cause problems. And one woman’s car stalled (pret) on the Lapinlahti bridge twice on subsequent mornings, precisely on the same spot. Around half past eight the
information department gets work to do. A coach has slid (perf) off the road on Turunväylä. The accident has not caused (perf) bodily harm but a traffic congestion has been created (perf).

The tenses of the first two paragraphs are quoted from Helin, the interviewee. In the first two perfects, Helin expressly avoids reference to individual cases. Telling which cases they were and when they happened is not just beside the point, but entirely out of the question. The less serious cases are told as anecdotes in narrative preterit. Although they too are brought up as examples of a generalisation, they are treated as individual incidences and described accordingly (eräs ‘one’).

The perfects of the last paragraph are not quotations, but eyewitness news told in historical present. A new situation has arisen and relayed to the center. Using a simple past would be out of place, because this bit is hot news relayed second hand to the reporter in a present tense account.

The Finnish perfect allows both tänään olet ollut täällä vuoden ‘today you have been here for a year’ here/ year<‘today and olet ollut täällä eilen ‘you apparently were here yesterday’ yesterday/here<‘now. Can we have both adverbs at once: tänään olet ollut täällä eilen ‘today you have been here yesterday’? Not very well. Having both adverbs at once is either inconsistent or redundant, not to mention split perspective. The adverbs combine inconsistently in here/year<‘today/yesterday, and redundantly in yesterday/here<‘now/ today. Olet eilen ollut täällä vuoden ‘you have been here for a year yesterday.’ denoting here/year<‘today is empty as well.

**Progressive**

Finnish grammar knows no progressive by that name. There are various periphrastic forms of restricted application: olla tulossa, tekemässä, tekeillä, tekemäisillään. ‘be on its way (lit. in arrival)’, be doing/making, be under preparation, be about to do/make’.

- Hän on tekemässä testamenttia. ‘He is (off/busy) drawing up (ine) a will.’
- Viime tiistaina Nina oli (kävi) pitämässä (ine) esitelmän Helsingissä. ‘Last Tuesday Nina was in (made a trip to) Helsinki to give a talk.’
- Hän on saamassa perinnön. ‘He is (about) to get (ine) an inheritance.’
- Hän on saamaisillään perinnön. ‘He is about to get (ade) an inheritance.’

The first form olla Vmassa ‘be in Ving’ is closest to the English progressive. It retains an implication of event taking place at a specific location (it answers a where question). This form is awkward if the location of the event in progress is not the location of the subject. It thus serves for an absentive progressive (de Groot 1998). Future and generic progressives like the following are therefore less likely: The object case is partitive on an interior progressive reading, accusative implies a cycle or a point progressive.

- Syö tavallisesti kotona, mutta ensi viikolla olen syömässä ulkona. ‘I usually eat at home, but next week I am eating out.’

These observations indicate that Finnish progressive has narrow (lexical) scope: only fut prog e and gen prog e are possible, not prog fut e or prog gen e as in English. This observation confirms a tendency observed elsewhere: what grammaticalisation does to an aspect is widen its scope, making it commutative with other operators of the event calculus.

In olla Vmaisillaan ‘be about to V, on the verge of Ving’ the reference time is at the very beginning of the event. Unlike accomplishments, achievements like voitaa ‘win/beat’ do not use total/partial object alternation Voitit hänet/voititin häntä ‘I beat him/I was beating him’ to express progressive. Instead, there are two periphrastic progressives olla Vmassa ‘to be in the process of’ and olla Vmaisillaan ‘to be on the point, verge of’. The former has an internal locative case, the latter a point progressive. The former is primarily absentive, the latter a point progressive I was about to beat him. Both are used with total object form Olin voittamassa/voittamaisillani hänet meaning ‘I was about to beat him’, preferably the latter. A minimal pair between interior and boundary readings is fi Massaturismi on valtaamassa Kenian/Keniaa ‘Mass tourism is about to/in the process of taking over Kenya (nom/ptv)’ (Tommola 1986:78).

The partial object form is an interior progressive, the total object a boundary progressive, denoting the verge of a complete takeover.

There is a duality between internal and external locative cases here. External cases are used generally for temporary states and postures: varpaissillaan ‘on tiptoe’, sukkaisillaan ‘in socks’, ilkosillaan ‘naked’, seisossaillaan ‘on foot’, vieraisilla ‘on a visit’. Dual minimal pairs are unessa/valveilla ‘awake (external case) / asleep (internal case)’, yhessä/erilläissä ‘together/separated’.

Finnish has no grammatical future either. Again, there are periphrases: tulla Vmaan, ‘come to V’, olla Vva ‘be Ving’. Both are remote futures; the latter is biblical, ‘be (destined) to’.
Icelandic

Carlota Smith in her *Parameter of Aspect* (1991:93) cites Icelandic (along with Finnish) as a language without grammatical aspect (‘grammaticized viewpoints’). It is true that the Scandinavian languages in general do not loom large in aspect literature. Specifically, two of the most prototypical aspect contrasts (perfective/imperfective, simple/progressive) are weakly grammaticalised compared to showcase aspect languages.228 Scandinavian languages in general have a well grammaticalised simple past/present perfect distinction. This is also true of Icelandic. In addition to Germanic style *be* and *have* perfects, Icelandic has another perfect like construction in *vera búinn* að + infinitive, lit. ‘be ready, done with V’. A relatively young arrival (attested in texts since 16th century), this construction appears to be under active development. It is spreading in colloquial language in competition with the older *hafa* + past participle perfect ‘have Ved’.

**Icelandic perfects**

There are three forms of perfect listed in Icelandic grammars: Germanic style *be* and *have* perfects and the *vera búinn* að + infinitive. Typical cases are

Skipið er farið fyrr lónu. ‘Das Schiff ist schon lange weg.’

Ég er búinn að lesa bókina (núna). ‘I have read the book (now).’

Hann hefur reykt pípu í mörg ár. ‘He has smoked the pipe for several years.’

The *vera* perfect seems a clear result perfect formalised as **búinn**. According to Jónsson (1992), the *vera* perfect does not harbor event modifiers:

*Jón er farinn gangandið fylti/oft/fýr hér/brýr til Boston. ‘John has already/just come to/arrived in Boston. (Jónsson)*

The *vera* perfect is formed from intransitive change and movement verbs. *Vera búinn* is extending to a variety of event types. By form, *vera búinn* is a *be* perfect from búa ‘make, build, live’, etymologically ‘be done with’. Kress (1982:155) in fact sets the *vera Vinn* perfect of intransitives and the *vera búinn* að V perfect of transitive event verbs in complementary distribution against the *hafa* perfect.229

The two *vera* perfects do appear in parallel in the following:

Heyrðu það er með fóðurblandustöðina í Landeyjunum. Nú er hún komin í gang og búið það er búið að prufakeyra. ‘Listen, this is from the fodder mixing station at Landeyjunum. It has now started and test runs have been made.’

However, something of a resultative vs. near past contrast can be felt between *vera Við* and *vera búinn*:

Skipið er farið fyrr lónu. ‘Das Schiff ist schon lange weg.’

Skipið er búið að blása tvissvar. ‘Das Schiff hat schon zweimal getutet (es ist höchste Zeit).’

Jónsson (1992:144) in fact feels *Jón er búinn að fara til Boston ‘John has gone to Boston’ cannot be used to indicate that John is already in Boston; *er farið* ‘is gone’ is reserved for that purpose. A similar implicature can be felt in *John has already/just gone to Boston. Fara ‘go’ has source perspective, so ‘go from’ is a change, ‘go to’ an accomplishment. Therefore only the ‘go from’ sense can be immediate, the ‘go to’ sense is bound to take time. In particular, *fara* cannot mean ‘arrive’. The missing meaning can be expressed with *John has already/just come to/arrived in Boston.*

The *hafa* perfect, unlike the *vera* perfect, has no entailments for the present. According to Kress (1982:153) *han hefur komin* means ‘er ist gekommen und ist wohl wieder fort’, while *hann er komin* ‘er ist gekommen und befindet sich hier’.230

If an event is separated from the present (say, by the death of an author), *búinn* feels unacceptable:

Shakespeare hefur samið/*er búinn að semja frábær leikrit. ‘Shakespeare has (*now) written impressive dramas.’ (Jónsson)

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229 “Die resultativ-situative Konjugation vom Type *vera búinn* að gera e-ð wird von transitiven Vorgangsverben gebildet. Sie ist das Gegenstück zum Typ *vera kominn*, der zu intransitiven Verben gebildet wird. Ähnlich wie *vera kominn* neben *hafa komið* steht, ist besonders in der modernen Umgangssprache *vera búinn* að gera e-ð neben *hafa gert e-ð* getreten.”
When there is a live contrast with the hafa perfect, the búinn perfect describes ‘separate, definite events that have been recently completed’ (Wide 1995). In contrast, the hafa perfect concerns ‘general, distant or repeated events’. Often, the contrast between búinn and hafa plays on result implicatures. Búinn strongly suggests that the results of the past event hold ‘now’.

This suggests búinn is a weakly perfective near perfect pf. e now. The older, unmarked hafa perfect covers existential (‘general, distant’) and open (‘repeated’) perfects. This speaks for a formalisation as an existential perfect e̵ now. This means that the búinn is optionally closed, and hafa optionally remote. The contrast can vanish, but comes out clearly in certain contexts.

Búinn appears to be the marked member of the two, gaining ground from hafa. (Wide 1995). It thus makes sense to describe it positively and then look at the leftover uses of the hafa perfect. I start the survey with lexical event types.

**Aktionsarten**

Kress (1982:153) assigns vera (búinn) perfects an active meaning: “das Subjekt hat den Vorgang (die Orts- bzw Zustandsveränderung) selbst ausgeführt”. According to Friðjónsson (1989:104) vera búinn að + infinitive is normally used with agitative animate subjects. In particular, it does not go with durative verbs, momentaneous verbs, or mental states of indefinite duration (Einarsson 1949:147). These restrictions would reflect the etymological complete sense ‘ready’ of búinn: it is agents who get done with what they set out to accomplish.

However, examples show that animacy or intentionality is not the current constraint, but rather, causality or resultativity. Búinn is fine with unintentional events if they have a result:

> Ég er búinn að gleyma því sem þu lofaðir í gár? ‘Hast du schon vergessen (weissst du nicht mehr) was du gestern versprechen hast?’
> Ég er búinn að týna lyknum. ‘I have lost the keys (the keys are lost).’
> Þokan fer mjög bratt og verður innan standar búin að umlykja okkur. ‘Der Nebel zieht ein und wird uns in Kürze eingehüllt haben (und gleich stecken wir darin).’

According to Einarsson (1949:147), verbs indicating the beginning or the end of an event don’t like búinn. One says ég er sofnadur ot ég hef sofnad. ‘I (must) have fallen asleep’, rarely ég er búinn að sofnu. ‘I have now fallen asleep’. Hann er búinn að deyja. ‘He is just done dying’ is no good. This too suggests that búinn has a preference for accomplishments over simple changes.

By the grammar books, states and activities go with búinn only to the extent they can be construed as accomplishments of some sort. Hún er búinn að lífa means she is through with life: “ihr Leben hat kein Sinn mehr”.

Börnin eru búinn að vera í baði (= baða sig). ‘Die Kinder haben schon gegaben.’ (Kress)

Hafa is the only option when the event type is open, and the question is what one has been doing rather than how long (Einarsson 1949:147).

> Ég hef staðið her. Mér hefur leiðið. ‘I have been standing here. I have been bored.’ (Kress)
> *Hann er búinn að standa við bordið. ‘He has stood by the table,’
> *Búinn er búinn að ryögu í vetur. ‘The car has rusted this winter.’ (Svávarsdottrídd/Jónssdottrídd)

Aspectual competition is found with adverbials of duration. As was pointed out earlier, durative time adverbials are a well known cause of derived perfectives. The fact that búinn can subsist on derived adverbial closure is a definite index of grammaticalisation.

> Hún hefur soyður búinn að sofa í allan dag. ‘She has slept all day.’
> Hún er búinn að liggja í rúminu *(í allan dag). ‘She has been lying in bed *(all day). (Jónsson)

**Examples with hafa perfect are common:**

> Ég hef verið á Islandi í tvö ár. ‘Ich bin seit zwei Jahren auf Island.’
> Ég hef notað þessa bok í mörg ár. ‘Ich benutze dieses Buch seit Jahren.’
> Ég hef þekkt hann, síðan við vorum börn. ‘Ich kenne ihn seit wir Kinder waren.’
> Ég hef verið að tala við hana í þrá tíma. ‘Ich rede schon seit drei Stunden mit ihr.’

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232 The adjectives ‘separate, definite events that have been recently completed’ vs. ‘general, distant or repeated events’ correspond to these formalisations to the letter. The búinn perfect is near (‘recently completed’ and perfective (closed ‘separate’ or unique ‘definite’).

233 Thus búinn does not translate McCawley’s ‘hot news’ perfect Dennis Brain has died in an auto accident.
In comparison, a universal búinn perfect adds an ‘already (by/until) now’ implicature.

Hann er búinn að sofa tvo tíma. ‘He has slept two hours now.’
Hann er búinn að veikur í finn ár. ‘Er ist schon fünf Jahre lang krank.’
Ég er búinn að standa hér síðan í morgun. ‘I have been standing here since morning.’
Þær eru búir að bíða svo lengi. ‘They have been waiting so long.’
Hún er búinn að vera partur af kvótaferfinu frá því að kvótaferfið var sett á. ‘It has been part of the quota system from the time the system was started.’

Thus Icelandic is able to disambiguate between the two readings of English ‘He has been awake for ten hours (now/before)’. A minimal pair (Friðjónsson 1989:106):

Hann hefur vakað í tiu tíma (aður). ‘He has been awake for ten hours (before).’
Hann er búinn að vaka í tiu tíma (núna). ‘He has been awake for ten hours (now).’

Universal perfect búinn makes is no suggestion of having finished. In fact, the opposite is the case; the result state is implied to persist (Bonner 1995:54):

Hún er búin að leiða blak í mórg ár (en ætlar að hætt á næstunni/*en er hætt núna).
‘Sie spielt schon seit Jahren Volleyball (will aber demnächst aufhören/*hat aber jetzt aufgehört).

But there are occurrences of universal perfect búinn also without a closing adverb in the same clause. The following example is a good instance of a bridge: the state duglegur ‗efficient‘ is immediately derived from an accomplishment múra inn ‗mortar in place‘

Gefum múraranum fri að þessu leyti. Hann er búinn að vera duglegur. Mára inn þusundir af baðkerum. ‘Let’s free the mason at this point. He has been efficient. Mortared in thousands of bathtubs.

Jón er búinn að vera í fríi. ‘John has been on vacation.’ (Jónsson)
Róbert er búinn að vera veikur. ‘Robert has been sick.’ (Jónsson)

Jónsson’s examples are compatible with being still on vacation or sick. Similar examples are easy to come by in spoken language data (Wide MS 1998):

Nei, ég er ekki af Suðurnesjum, ég er bara búin að búa hér. ‘No, I am not from Suðurnes, I have only lived here’.
Akkúrat, ég er búinn að vera að meta þeim núna, svona það má segja um helgar sérstaklega. ‘Exactly, I have been bumping into them now, that is to say on weekends in particular.’
Ég er nú búinn að vera að hlusta á ykkur voðalega mikið. ‘I have now been listening to you quite a lot.’
Ég þekki marga sjúkl-/marga áfengissjúklinga og ég er búinn að vera mikið í kringum áfengissjúklinga og og þett- þetta gengur bara svona. ‘I know many alcoholics and I have been a lot around alcoholics and that just is how it goes.’

Wide’s first example clearly suggests that the speaker still lives there. What is preserved is the sense of near perfect (by/until) now as opposed to an existential or generic sense (once/generally), which would in turn be implicated with a bare hafa perfect.

Quantifiers
Notwithstanding the competition, a survey of cases shows that a closed-open (universal-existential) duality persists in the búinn/hafa opposition.

Búinn adds the implicatures of yet in negative sentences. This kind of at all/yet contrast closely resembles the imperfective-perfective distinction in Russian (Leinonen 1982):

Maria hefur ekki bakað/er ekki búin að baka köku. ‘Maria has not baked a cake (at all/yet).’
Ja esche ne (pro)chítal etu stat’ju. ‘I have not yet read (any/all of) this paper.’
Ég bara vil oska þess að fólk sem að er ekki búin að búin að hugsa sig um að það kjósi up Pétur Hafstein þvi hann er alveg –o– alveg mjög…
‘I just want to wish that people who have not yet made up their minds that they should vote for P.H. for he is very – very much…’
Já, Sigurjón Karlsson er órunglega ekki búinn að skökkva á útvarpinu þannig að þetta… ‘Yes, S.K. has surely not turned off the receiver yet so that this…

234 Wide (forthcoming) points out that many of the examples involve vera as the complement verb.
Negative existential quantification over events (aldrei ‘never’) favors hafa, as do negative polarity contexts (‘not/if ever/at all’) in general:

ET er besta mynd sem ég hef nokkur tíman þétt* er nokkurn tíman þétt að sjá. ‘ET is the best movie I have ever seen.’ (Jónsson)

Þar hefur aldrei verið einhugur um framboð. ‘There has never been unanimity about candidacy.’ ¬(unanimity<now)

Auka á afkast og og meira mæli en hefur verið gert hingað til… ‘More openly and more loudly than has been done hitherto…’

Universal quantification (alla tið ‘always’) is commonly found with búinn.

Við eru búnir að verða fyrir þessu þarna. ‘There are so many who have come against this in the municipal cemetery (at one time or other) and now I have come against this there.’

Búinn and hafa appear contrastively in the following polarity contrasts:

Ég held að ég sé eini frambjóðandinn sem ekki hefur hafað sjónvarpsauglýsingar. ‘I think I am the only candidate who has not had TV commercials. I think all the other candidates have be-…’

A: Og ég er búin að tala við þau á Náttúrgripasafni og þeir taka nú ekki svona hluti. … B: En hefurðu ekkert talked við hann Ævar Pedersen fuglafræðing hjá Náttúrfræðistofnuninni… ‘A: I have (already) talked with the people at Natural Museum. and they do not take such things. A: But haven’t you talked with Ævar Pedersen at the Institute of Natural Sciences?…’

A near-remote (generic) contrast is found in the following cases

Hún er búin að vera atvinnulaus…. ‘There has been a lot of pressure, and it has been on the increase, from the ship owners, that it should be rescinded.’

A process-result contrast appears here:

Ég er nú búin að eiga marga syni og fjorir af þeim finn eru - hafa verið mikið á sjó og tveir eru sko atvinnusjómaður sjómenn.

Again, Russian favors imperfective in negative existentials (Leinonen 1982).
‘I have had many sons now and four of the five have been a lot at sea and two are professional sailormen.’

**Adverbials**


Hann er búinn að sjá myndina (núna, nýlega). ‘He has seen the movie (now, recently)’. pf see now

Hann hefur séð myndina (oft, áður). ‘He has seen the movie (often, before).’ pf see< now

These adverbials are often supplied in translation to bring out the near past implication of búinn:236

Síf er búinn að finna bókina. ‘Síf has found the book (now).’

Síggí og Inga eru búinn að gíf fa sig. ‘Síggí and Inga have kindly geheirarat.’

Eruð þið búinar að fá háusnæði? ‘Have you (already) been given a house?’

Értu þetta að skipta um skoðun? ‘Have you changed opinion now?’

Ég er búinn að fullkennu þetta. ‘I have already checked this thoroughly.’

Pað maður er búinn að keyra lengi og er ekkert með alveg ný rettindi. ‘That man has already driven a long time and has by no means a new licence.’237

A good example of the near past implication of búinn is

Allir þeir sem að eru búinir að fá bilpróf og eiga að aka um götturnar … eiga að víta þetta.

‘All those who (just/recently) got a driver’s licence and are supposed to be driving around the streets ought to know this.’

The speaker is talking about inexperienced drivers, not any and all people who hold a driver’s licence. There is no word just in the Icelandic original. There is a nice contrast between remote and near perfects in the following examples from Wide (MS 1998):

Þetta gamla móðstýrða verðkerfi á fiski hefur gengið sér til húðar…. Fiskverð er búið að vera frjáls í tvö ár. ‘This old centralised fish pricing system has become obsolete. Fish prices have been free for two years now.’

Veistu það ég er búinn að vera að ferðast um landið núna með útlendinga og véðrid hér hefur verið eins og eftir póntun. ‘You know I have been traveling around the country now with foreigners and the weather has been as if it had been ordered.’

Þeir hafa sött til dæmis allan garðaúrgang. Núna bara i þó nokkuð mórg ár. Nei, nú er búið að loka fyrir þetta.

‘They have collected all the garden waste for instance. For quite a few years now. But now this has been stopped.’

Értu þetta að skipta um skoðun? Nei það sem ég hef verið að tala um áður mig langar ekki að verða höfðingi…

‘Have you changed opinion now? No, what I have been talking about (earlier) is that I don’t want to become a leader…’

The old pricing system became obsolete some time ago, for the free price system has been in force for two years. The tourist guide has just returned from the journey, during which the weather was generally fine. The municipality used to take care of the garden waste, but now the service has been discontinued. What the candidate has just said is not incompatible what he has been saying before.

According to Svavarðsdóttir/Lónsdóttir (1988:183), there is no difference between hafa + supine and vera búinn að + infinitive when they express how often or many times something has occurred.

Hún hefur oft lesið/ er oft búinn að lesa bókina. ‘She has read the book often/many times’. pf read<? now / pf read now

Absolute frequency is number of occurrences, relative frequency is number of occurrences per time. The former is closed, the latter open. Hafa seems the unmarked form for relative frequency, búinn when for absolute frequency.

Ég hef talad við hana tvisvar eða örisvar. ‘Ich habe zwei- oder dreimal (selten) mit ihr geredet.’

Ég er búinn að verða tvisvar sinnum fyrir þvi núna. ‘I have come against this (altogether) two times now.’


237The last two examples reflect my discussion of the dual senses of already (‘early’ vs ‘long’) below.
Hún hefur margofr reiðiXX/er margofr búin að reiðast við mig. ‘She has been angry with me very often.’
Barnið er báði að detta mörgum sinnum. ‘The child has fallen several times.’

The open/closed aspect difference of the English relative/absolute frequency adverbials often/many times is in many languages (e.g. Portuguese) reflected in the choice of open/closed aspect of the verb:
Ele deu muitos livros às crianças. ‘He gave (pf) many books to his children.’
Ele dava muitos livros às crianças. ‘He often gave (impf) books to his children’

In a closed period, often and many times come out as equivalent: if an event happens many times during the period, it happens often, and conversely.

Jónsson (1992:140) stars búinn in the following sentence:

*Jón er yrfileitt búinn að svara í simann þegar ég hringi. ‘John has usually answered the phone when I ring.’

**Tenses**

As in English (and unlike German), the bare hafa perfect is not future. futurum exactum is expressed with verða búinn or mun hafa.

*Ég hef leíð bokina á morgun. *I have read the book by tomorrow. Bis morgen habe ich das Buch gelesen.
Ég verð búin að lesa/mun hafa lesXX bókina á morgun.

The English perfect as a rule does not go with future time adverbials like tomorrow, next week, a week from now (Crystal 1966, Matthews 1987:145). There is no progressive perfect in English (Mittwoch 1988:243) because having done something is a simple state.238

I am nearly having written this paper.

In contrast, the future perfect verða búinn ‘get ready, finished’ does have a point progressive (prospective progressive):

Peir eru alveg að verða búnir að borda. ‘They are about to finish eating.’
Ég fer að verða búin að fá nóg af þessu. ‘I am about to have had enough of this.’

The hafa and búinn perfects tend to fall together in the past tense. It is well known that the perfect/simple past distinction tends to vanish in the pluperfect (e.g. English, Finnish).

Hann hafði vaskað/var þáinn að vaska upp þegar hún kom heim. ‘He had washed the dishes when she came home.’
Peir þeir höfðu hvílt/vöru búnir að hvíla sig föru þeir að vinn. ‘When they had rested they started working.
(Friðjónsson 1989:106).

**Discourse**

The semantic differences between the Icelandic perfects have reflexes in discourse structure. This section surveys some of them.

**Aboutness**

Kress (1982:155) points out that the questions different perfects answer in discourse are different Búinn perfects are specifically about now as opposed to the past; hafa perfects are not.239

Jón hefur smíðað skápinn. ‘Jón (und kein anderer) hat den Schrank angefertigt.’
Jón er búnir að smiða skápinn. ‘John hat den Schrank fertig (man kann ihn jetzt benutzen).’

This is just one of the places where contrasts concern what questions perfects answer. The question test reveals what a discourse move is about. This is a discourse matter which can be represented in terms of the dialogue game model of discourse (Carlson 1983).

What is the contrast between present (perfect) and simple past (perfect)? Loosely speaking, it is a difference in what the sentence is about: the present (perfect) is about the present time, the simple past (perfect) is about the past.

238Hirtle (1975:26-27): “[Perfect] constitutes an event which can never suffer any development or change, a fact which explains why it is not possible to have the progressive [perfect]”.
239’Sie stellen einen Zustand für einen bestimmten Zeitpunkt im gegensatz zur Zeitspanne vorher als neu, eben erreicht hin’ (Kress 1982:153). Kress’ gloss for vera búnir að gleyma is ‘schon vergessen haben.’
It only becomes obvious what is being talked about when more than one thing is said about the same thing. There are two ways in (natural or formal) language to say several things about the same thing. One is variable sharing, the other is function composition. In natural language, these methods are exemplified by anaphoric reference (*Something happened* and *it was unexpected*) and syntactic subordination (*Something unexpected happened*). The former is formalised using variables and the latter by function composition.

For instance, the event type $e \cap \text{then} \cap \text{now}$ denotes the whole course of events from $e$ to now but refers with *then* to $e$. The event type $e \cap \text{now}$ entails the course of events from $e$ to now but denotes now. It is always possible to translate from one representation to the other. Tenses or phasal aspects may thus differ only in what they are about: they entail the same course of events, but denote or refer to different phases of it.

- An indefinite past $e \cap \text{now}$ can be narrowed down to a narrative or definite simple past $e \cap \text{then} \cap \text{now}$ or to an existential perfect $e \cap \text{then} \cap \text{now}$.
- A near past $e \cap \text{now}$ can be narrowed down to a near perfect $e \cap \text{then} \cap \text{now}$.

The referential distinction is reflected in discourse. Present Perfects take part in present tense arguments. For instance, an existential perfect contradicts an open near past, and a present state entails the negation of a result perfect.

### Indexicality

In her study of the Icelandic presidential election debate, Wide (MS 1998) notes that the *búinn* perfect in conversation is indexical: it serves connect up the discussion to here and now, which may be the current conversation situation, the situation of the election campaign, or the current global situation. This is a good example of invariance of indexical meaning on varying levels of resolution. Given the indexicality of *búinn* as against the generic *hafa*, it is a likely conjecture that *búinn* is relatively more frequent in first and second persons, while *hafa* favors third person.  

### Definiteness

Icelandic grammarians have also noted a connection between the definiteness of an object and choice of perfect:

*Ég hef séð isbjörn* ‘I have seen a polar bear.’
*Ég er búinn að sjá isbjörnin.* ‘I have seen the polar bear.’

This again accords with similar findings in Russian (Leinonen 1982). An indefinite object creates an indefinite, hence iterable event type and goes with open aspect; a singular definite one individuates a specific event and goes with closed aspect:

$V \text{ etom meste ja kogda-to naxodil belyje griby/nashel belyj grib}$.
‘Here I have once found (ipf) mushrooms/ found (pf) a mushroom.’

### Specificity

Icelandig *hafa* perfect has evidential uses:

‘A: John climbed on the roof and started to sing. B: He must have been drunk. (Jónsson)***

In Icelandic too, definite past adverbials go with evidential present perfect:

*$\text{Jón hefur verið fullur i gær. ‘John must have been drunk yesterday.’}$
*$\text{Hún hefur verið að reyna að komast inn um gluggann i gær. ‘She apparently tried to get in through the window yesterday.’}$
*$\text{Hún hefur farði að finna til þreytu i gær. ‘She must have started feeling tired yesterday.’}$
*$\text{Ja, ef ef þu hefur hlustað á Alþingi um daginn…‘Yes, if if you listened to the Parliament the other day…’}$

There is one instance of *búinn* with a definite past adverbial in Wide’s data, and it is not evidential:

*$\text{Ég er búinn að heyra i gær sko þvi þá hlustaði ég fyrst á aftur sko ég tapaði þessu. ‘I have heard about it yesterday I like listened at first and then I like missed it.}$

A contrast between a witnessed *búinn* and an evidential *hafa* seems discernible at times:

*S: Hann er búinn að segja það opinberlega hann Ólafur að að allt sem kemur í hans kosningarstjóð og hvernig hans baráttu er strykta mun verða birt opinberlega að baráttunni lokinni. O: En en en þá hefur kannski tekið eftir og fleiri að það er áberandi hvað Stöð 2 er hlutdræg í þessu…*
'S: He (Olafur) has said that obviously, all that comes to his electoral expense fund and how his campaign is sponsored may be openly divulged when the campaign is over. O: But there perhaps more people have become aware that it is obvious how Station 2 is partial in this…'

A quotative perfect is a relative of evidential perfect. Icelandic regularly uses subjunctive perfect in indirect speech: 

…. han segir mér það að hann sé búinn að sjá mig standa á stoppustöðinni. … sem sagt hann bara sá mig þarna… 'He says to me that he saw me stand at the bus stop. … as I said he just saw me there…

….mér finnst engu máli skipta hvort það er Jón Bladvin sem hafi velt henni upp eða einhver annar. 'To me it makes no difference whether it is J.B. who has turned it up or someone else.

Búinn as a perfect type

The prototype accomplishment is the causative construction p cause r where a process p causes a result state r. Ready (finished) as a lexical entry produces a result state out of an accomplishment: one is ready (finished, done) with something when the preparatory process has caused the end result. This establishes accomplishment as the prototypical input Aktionsart of búinn.

As for the output aspect, búinn is etymologically a near past, not unlike Portugues acabar de ‘finish’ or French venir de ‘come from’. These are phasal aspects, denoting a result phase near the end of an event. The immediacy is due to resolution. One is ready/through/done with an event briefly after the end of the event. The finish of an event is a fraction of the entire event, which means that the neighborhood of the finish is shorter than that of the entire event: the scales are different. In particular, subsequent events on the same level of resolution, in the same course of events, separate the aftermath of the event from the present.

In present day Icelandic - spoken language in particular - the closed/unmarked contrast between búinn/hafa perfects is treading to the background, and the contrast is becoming a near/unmarked contrast. The field of aspectual competition appears to be universal perfect, where búinn is ousting out hafa. spreading from adverbially closed cases to contextually closed ones. The developmental states of Icelandic perfects are shown in Table 3.
Mainland Scandinavian

The NORDSEM project on Comparative Semantics for Nordic Languages has recently conducted comparative semantic studies on the three mainland Scandinavian languages Swedish, Danish, and Norwegian. Elisabet Engdahl's study of comparing the bli and s passives in the three languages is interesting from the present point of view, for it bears out some of my typological expectations about the difference between effect participle passives and reflexive (medial) passives.

Cause/effect nominalisations turn transitive verbs into complements (deverbal nouns) or adjuncts of other events (gerunds) or objects (participles).

\[
p: p(x) \text{ cause } q \quad \text{cause nominalisation ('present imperfactive active')}
\]
\[
q: p \text{ cause } q(y) \quad \text{effect nominalisation ('past perfect passive')}
\]

Cause/effect participles in particular denote the subject of the cause or effect:

\[
x: p: p(x) \text{ cause } q \quad \text{'(one who is) Ven'}
\]
\[
y: q: p \text{ cause } q(y) \quad \text{'(one who is) Ved'}
\]

Composition of new finite forms from deverbal nominalisations with or without finite auxiliary verb is a main avenue to grammatical innovation. One of the commonest types of periphrasis is the become Ven type passive periphrasis, which is a verbatim rendering for the Scandinavian bli passive (bli vald is literally become elected).

\[
\text{become y: p cause } q(y)\quad \text{'get Ven'}
\]

Voice is grammatical change of diathesis. The commonest sources of voice are the become Ven type passive and reflexive passive:

\[
\text{pass p cause q = q: p cause q}
\]
\[
\text{refl p cause q = p(x) cause q(x)}
\]

Etymologically, the Scandinavian s passive derives from the reflexive pronoun sig > sik > st > s, and it has many reflexive, reciprocal or medial uses: vi ses 'we see each other', fy skäms 'be ashamed of yourself' du tröttas lätt 'you get tired easily'.

Engdahl shows that the division of labor between the two passives is different in Swedish and the other two mainland Scandinavian languages. In brief, the Swedish bli passive is less grammaticalised than in the other two languages; while the opposite is true of the s passive. In Swedish, the s passive is the unmarked passive, while the range of the bli passive is easier to describe positively. In Swedish, the bli passive remains close to its compositional meaning 'become Ved':

- The subject of bli remains a subject of a predicative clause
- The event type of bli remains a true change
- The subject of the s passive is not an agent.

Engdahl produces evidence for these observations. The Swedish bli passive does not support presentational formal subject, unlike the s passive:

Mycket öl blir drucket i Sverige.?Det blir drucket mycket öl i Sverige. Det dricks mycket öl i Sverige. 'A lot of beer gets drunk in Sweden'.

The s passive supports a subjectless raising verb, the bli passive does not:

Det antas att sossarna vinner valet. Sossarna antas vinna valet. ?Det blir antaget at sossarna vinner valet. ?Sossarna blir antagna at vinna valet. 'The socialists are supposed to win the election.'

The subject of bli can be bound by an equi verb, while the nonagentive subject of the s passive can not:

Representanten försökte bli omvald/?omväljas. 'The representative tried to get re-elected.'

The bli passive supports imperative, the s passive does not:

Bli inte rånad/?rånas inte i Chicago!

Attitude adverbials modify the agent of a s passive but remain ambiguous with the bli passive:

Flyktingar tas inte gärna emot. 'Refugees are not received willingly.'
Flyktingar blir gärna mottagna af Röda Kors. 'Refugees get willingly received by the Red Cross.'
The same difference can be felt between the English *be* and *get* passives: the *get* passive allows a reflexive agentive reading 'let themselves be received'.

The different subject properties of the two passives indirectly disambiguate between the dynamic or epistemic ('subjective') readings of *kan* 'can' from a deontic ('non-subjective') reading.

- Man kan bli påkörd/?påköras. 'One can get run over.'
- Kursen kan tenteras/?bli tenterad. 'One can get examined on the course.'

The dynamic or epistemic readings of the first *kan* example imply a change in the subject, while the deontic reading of the second example affects the student, not the course. The difference is clearly felt by transforming *X kan* to *det är möjligt för X att*:

- Det är möjligt för en att bli påkörd. 'It is possible for one to become run over.'
- Det är möjligt för en att tentera kursen. 'It is possible for one to get examined on the course.'

In Danish, the auxiliary *vil* is ambiguous between deontic and epistemic senses (want and future). Again, the deontic sense goes with the *s* passive and the epistemic sense with the *bli* passive.

- Han vil roses/blive rost. 'He wants to/will be praised.'

**Bli** passive is formed of a verb only if the verb is a change causative:

- Nödropet hördes av en fiskare. ?Nödropet blev hörd av en fiskare. 'The cry of distress was heard by a fisherman.'
- Han överfölls/blev överfallen av rånare. Han överfölls/?blev överfallen av ånger. 'He was taken over by robbers/remember.

As a result, the two passives disambiguate between event and state senses of verbs of communication and perception such as *säga* 'say: utter/mean' and *se* 'see: spot/consider'.

- Det sägs/?blir sagt i FN's deklaration att alla är berättigade... 'It says/?gets said in the UN declaration that everyone is entitled …'
- Socialdemokraterna sågs allmänt/?blev allmänt sedda som lite maktfullkomliga. 'The social democrats were generally seen to be somewhat dictatorial'.
- En karl hade blivit sedd med diskförkläde i grannhuset. 'A man had been spotted wearing an apron in the neighboring house.'

In summary, the conclusion is that in Swedish, the *bli* passive is a compositional, marked construction, while the *s* passive is grammaticalised. The subject of a *s* passive is a non-agent, while the *bli* passive as a compositional predicative construction is neutral about the role of its subject. Engdahl in fact notes that a large share of *bli* passives have animate subjects.241 *Bli* is a marked event passive, which by paradigmatic contrast pushes the less marked *s* passive toward a state passive.

In Danish and Norwegian, markedness goes the opposite way. The *s* passive is an aspectually open, generic state passive. Though the subject is not an agent, a trace of the reflexive etymology is retained when the event type is treated as dispositional property of subject (compare *the book sells well*).

Gammelt jern köpes og selges. 'Old iron bought and sold.'

In these languages, the *s* passive mainly appears in the present tense and in infinitives. The *s* passive is not used to refer to event tokens.

- Vi så vinduet ?åbnes/blive åbnet. 'We saw the window be opened'.

An exception is a progressive use of the *s* passive in fiction analogous to the French *imparfait pittoresque* or the Portuguese *pitoresco*:

- Lansamt drejes nøglen om. Håndtaget trykkes ned og døren går op. 'Slowly the key is turned in the lock. The handle is pressed down and the door opens.'

The *bli* passive is less constrained in Danish and Norwegian than in Swedish. As in Swedish, it is an event passive not normally used for dispositional properties:

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241 In fact all of the verbs listed for allowing both passives by Engdahl also allow animate objects.
Døren åpnes/?blir åpnet utover. 'The door opens outward.'
Kaninerne kan blive spist av ræven. 'Rabbits can get eaten by the fox.'
Spidsmus kan ikke spises. 'Shrews cannot be eaten (are inedible).'

with the paraphrases 'it happens to rabbits that they get eaten up by a fox' and 'it is not feasible for people to eat any shrew'. The crux remains whether a change is implied in the subject of the clause.

However, unlike Swedish, in Danish or Norwegian the bli passive can have a formal subject:

Ved slike leiligheder blir der ikke stort drukket. 'On such occasions (there is) not a lot gets drunk.'
Hun bliver anset at være klog. 'She is said/supposed to be clever.'
Mannen bliver tit set gå over gaden. 'The man is often seen to cross the street.'

Chinese
For Chinese, I try to fit interpreted data from second hand sources to my theoretical grid, which is likely to make the story simpler than real life. My sources here include Henne et al. (1977), Li and Thompson (1981), Smith (1991), Ritter/Rosen (2000).

(Mandarin) Chinese is an example of a language where tense and aspect markings are not inflections but more or less optional particles. The same goes for number, which leaves a lot of vagueness in event types for context to decide. Context permitting, markings may be omitted:

Zhangsan xiuli yige luyinji. ‘Zhangsan repaired/is repairing a tape recorder.’
Ta hai zai (prog) xiuli ma? Ta xiuli-hao-le (pf) ma? ‘Is he still repairing it?’

Xiali-le. ‘He stopped repairing it.’
Xiuli-hao-le. ‘He fixed it up.’

Tense and aspect particles, time adverbials, and specificity take turns to express the desired temporal entailments.

A significant aspect type in Chinese are acquisitions, which include temporary states and position and location verbs.

The change and result senses are told apart using perfective le and resultative zhe:

Mali chuan yijian maozi. ‘Mary is putting on a hat.’
Mali chuan-zhe maozi. ‘Mary is wearing a hat.’

Aktionsarten
I noticed that many English verbs of application or consumption like paint, eat, use are vague between activity and accomplishment. A formalisation suggested for such event types is pUc:pNc which literally denotes ‘a process producing a change, or a change produced by a process’. Chinese xue ‘learn’ is similar: it is vague between ‘learn’ and ‘study to learn’. The same formalisation seems right for a large class of Chinese extended event types: na ‘pick’, xie ‘write’, xiuli ‘repair’. The accomplishment sense is brought out with bounding particles, not unlike English verb particles: na-qi ‘pick up’, xie-wan ‘write up’, xiuli-hao ‘fix up’. Etymologically, such particles come from directional adverbs (qi ‘up’), support verbs (wan ‘finish’) and result adjectives (hao ‘good’).

Without a bounding particle, a perfective like xue-le is vague between a bounded activity ‘stop learning’ and an accomplishment ‘complete learning’, though the accomplishment sense dominates in the absence of evidence to the contrary. Example:

Zhangsan xue-le Fa-wen, keshi hai mei xue-hui. ‘Zhangsan studied French, but never actually learned it.’

The type of object influences the preferences in the usual way: indefinite noncount objects suggest an activity, a definite singular object an accomplishment. If the object is definite, a bounding prefix adds a success implicature ‘I bought up the book after all’. Recall that the Russian perfective has similar implicatures.

Wo mai-le shu. ‘I bought (pf) some books/the book’.
Wo mai-dao-le shu. ‘I bought (pf) up (dao) the book.’

242 Engdahl notes that öppna (causative of the adjective öppen ‘open’ derived from opp ‘up’) is one of a set of verbs that only have an s passive: bli öppnad is unattested. This is one of the verbs that have an inchoative or reflexive variant in other languages: English open, Finnish aueta, avaautua. My guess is that a shortest access principle is operative here (bli öppnad = bli öppen, öppna sig).
Perfective *le*

Mandarin Chinese (Li et al. 1982) has two aspect particles *le*. One occurs right after the verb as a perfective suffix. In accordance with the usual markedness defaults it is normally taken to make reference to the past. However, perfective *le* is not specifically past; it can be bound to any indexical time reference:

Ta chi *le* fan, jiu kan bao (*le*). 'After eating, he read(s) the newspaper.'

Like the Portuguese *perfeito*, perfective *le* is unmarked for present vs. past focus, so it translates both English perfect and simple past:

Ta gao *le* san cun. 'He grew/has grown 3 inches.'

Smith (1991:346) suggests that *le* does not apply to states. It does apply to acquisitions to produce inceptive changes and to temporally bounded states to produce cycles:

Wo bing-*le* ‘I got sick’
Wo zai nali zhu-*le* liang-ge yue. ‘I lived there for two months.’

Perfective *le* does not imply result, only closure; resultativity is marked with bounding particles (Smith 1991:108):

Wo zuotian xie-*le* yifeng xin. ‘I wrote a letter yesterday, but didn’t write it up.’
Wo zuotian xie-wan-*le* yifeng zin. ‘Yesterday I wrote up a letter.’

Perfective *le* contrasts with perfective perfect *guo* in that the former allows the result to persist, while the latter excludes it:

Wo shuaiduuan-*le*/*guo* tui. I have broken by leg (it is (not) broken still in a cast/it has healed since).

Perfective *le* contrasts with imperfective *zhe* in the presence of durative adverbials:

Miào mén hái guan-*zhe*. ‘The temple doors are still closed.’
Guan-*le* ji tian mén. ‘The doors were closed for a few days.’

Negative perfective is expressed by the perfect(ive) negation *mei(you)* ‘(has) not’:

mén *mei(you)* guan ‘the doors were not closed’,
ta *mei(you)* kan bao ‘He has not read the newspaper’.

Extended now *le*

The other *le* is placed at the end of sentence and acts as a conversational particle with the approximate force of *(by) now* contrasting the reference time to what went before. Consequently, the sentence final *le* can be glossed ‘now, already, so far, yet, anymore, this time’. It occurs alone in examples like

Hai, Gua-Gua! ni wang bei-fang qu *le*! ‘Hey, Quack-Quack! You are going north now (not south)!’
Ta zhidao nei-ge xiaoxi *le*. ‘She knows the news now (she hadn’t before).’
(Have you got dumplings?) Mei-you *le*. ‘Not anymore (we’ve run out).’
Xia you *le*. ‘(Why,) it is raining now (I didn’t notice before).’
Xiao Huang kuai yao lai *le*. (Hurry!) Little Huang is coming already!
Hao, hao, mashang *le*. ‘Ok, ok, coming (I’m bringing it already)!
Wo bu chi *le*. ‘I am not eating anymore (I’ve had enough)’. 
Bie mi-*le*. ‘Don’t lose your way (again, this time)’.
Tang re *le*. ‘The soup is (has gotten) hot enough by now’.

Extended now *le* clauses are negated with *bu*:

wo *bu chi* le ‘I am not eating anymore’, 
*bu xia* *le* ‘It is not raining anymore’.

The extended now *le* need not denote the indexical present:

Xia you *le* meiyou? ‘Had it started raining yet?’
Houlai baba bu fangyang *le*. ‘Afterwards daddy did not herd sheep anymore’.

With future adverbials, extended now *le* produces a near future:

Wo jiu yao chi fan *le*. ‘I’m about to eat.’

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243Li et al. (1980:42) suggest the two *le* have different etymologies: the perfective *le* derived from *liao* ‘finish’, the extended now *le* from *lai* ‘come’. This agrees with universal development tendencies (perfectives come from ‘finish’, near pasts from ‘come’).
Women kuai yao shang ke le. 'We're going to class.'

Extended now le is compatible with proper past adverbials, which indicates it is weak (loose):

Wo zuotian dao Zhang jia chi fan le. 'I went to the Changs for dinner yesterday.'

The difference between the two le is apparent in

Ta fuqin bing le sannian. Ta xianzai hao le. 'His father was sick for 3 years. Now he is well again.'

The contrast is visible with imperatives too:

Bie kan shu le! 'Don't cut trees (any longer)!

Bie kan neike shu! 'Don't cut down that tree!'

The combination of the two le particles is a Chinese way to form a perfect:

Wo zuotian zuo le yi jian huai shi le. 'I did a bad thing yesterday.'

Tang shi san-bai-shou wo bei chu lai yi ban le 'I have memorised half of the 300 Tang poems now.'

Wo zai nali zhu le liang ge yue yue le. 'I have lived there for two months.'

Lai le san tian le. 'It is three days since he came.' (lit. He came three days ago now.)

Wo he le san bei le! 'I've already drunk three glasses!'

Assuming sentence final le has the same aspect ¬ee as English already, we can predict this outcome in just the same way as for Portuguese já plus Perfeito. With a closed event, the sentence final le yields ¬ee¬eft which is a perfective near past, i.e. a closed near perfect. (Le is not as strong as already in that the scalar implicature as early as is absent.)

Universal (open near) perfect sentences are constructed with the extended now le alone, while zicong 'since' takes present tense:

Wo mingbai zhe ge wenti yige xiaoshi le. 'I have understood that question for an hour.'

Zicong ta zoule yihou, wo yizhi lao bu fanxin. 'Ever since he left, I've been worried all the time.'

Just as in Russian, perfective perfect of an open event means at all, while for a closed event, it means entirely:

Ni chi fan le ma? 'How are you (lit. have you been eating lately)?)'

Ni chile fan le ma? 'Have you had your meal yet (care to join us)'

Ni kan bao le meiyou? 'Did you see the paper (have you been reading it) yet?'

Ni kanle bao le meiyou? 'Have you finished reading the paper already (can I have it)?

The reference time can be past or future as well as present:

(nei tian) ta qu mai donxi le. (That day) he had gone out shopping.

(xia ge yue) wo jiu zai Riben le. (Next month) I will be already in Japan.

As can be expected, extended now le is not used to move a narrative forward, but to provide background:

Nei-shi, wo zheng hua zhe lao er yijing bage yue le. 'That time, I was already eight months pregnant with my second child.'

Li et al. (1980) argue that le is a pragmatic or discourse particle indicating current relevance of a state. I do not disagree: the description fits the formalisation ¬er¬eftnow/then and its closest English gloss (by) now/then. The particle indicates a current state, because it matches a state with a reference time, and it underlines its relevance, by entailing that the state is recent. I also agree with Li et al. (1980), that the eight or more different uses of le are best derived from the interplay of a core meaning with contexts of use. Among the clearest examples of derived discourse uses of le are

Zhe-ge mugua hen tian le. 'Why, this papaya is indeed sweet.'

Xia yu le. 'Well now, it is raining!'

Zhe shi yingwu le! 'Look, there is a parrot now!'

Here, it is someone’s assumptions about the situation that have changed, not the situation described.

Interactions

The optionality of TA markings makes Chinese a particularly interesting test case for the interaction of TA definitions. The prediction is that a marking may be left out just when its contribution can be inferred from the remaining exponents.

Consider now the combinations. Perfective le alone on an open event type tends to be understood as relative aspect. The sentence can be saved by a bounding complement, or an extended now le must be added:
Wo zuotian jie le shu … ‘After I borrowed books yesterday…’
Wo zuotian jie le lianshen shu. ‘Yesterday I borrowed two books.’
Wo zuotian jie le shu le. ‘I borrowed books yesterday.’

Sentence final le alone suffices when the event type is closed:
Ni hui-lai le. ‘You’ve come back (to roommate just returned from class).’
Ta qu mai donxi le. ‘He’s gone shopping (lit. He go buy things now).’

Perfective le is not needed either in the presence of a past time adverbial:
Wo zuotian jie le shu le. ‘I borrowed books yesterday.’
Ta zaoshang gaosong wo le. ‘He told me this morning.’

A past open event type closed by a complement practically calls for perfective le (Henne 1977:122).

Haiwa fang le liu nian yang. ‘Haiwa herded sheep for six years.’
Wo zuotian yujian le hen duo pengyou. ‘I met a lot of friends yesterday.’

Existential perfect guo
Mandarin remote perfect guo is etymologically a reduct of the action verb guo ‘pass’ (Henne et al. 1977:129, Cohen 1989:62). Smith (1991) claims guo cannot be conveyed directly by an English translation (meaning there is no exactly corresponding aspect in English). Examples:

Tamen shang-ge yue qu-guo Xiang Gang. *Hai zai nar. ‘They were to Hong Kong last month. *They are still there.’
Wo bing guo. ‘I was sick for a while’ (the illness is over).

In accordance with its etymology, guo entails that the event type is over (Smith 1991:348,352). For go, the result state is be in Hong Kong, so Mali went to Hong Kong, was there, and left. For (get) sick, the result state is be sick, so I got sick, was sick and got better. Thus guo is a way to produce cycles (of which the verb pass is a prime example). One way to represent guo is as the perfective of a resultative, pf res e, i.e. (e\r),¬r. The event type (e\r),¬r ‘the result state of e is over’ is close to the indefinite perfect e<`r ‘the event e is past’ (the former entails the latter; the latter allows but does not entail that the result state is over). Chinese guo is in fact used for existential perfect:

Ni chi-guo Zhongguo fan meiyou? ‘Have you ever eaten Mandarin foo?’ Yes I have (once).’
Ta fanyi guo yiben shu. ‘He has translated a book (once).’
Zhangsan chi-guo fan meiyou? ‘Has Zhangsan eaten yet?’

Hence the minimal pairs

Wo mai(le/guo) yiben youming de xiaoshuo. I (have/once) bought a famous novel.
Ta mei lai(guo). ‘He hasn’t arrived/been here’.

Guo is also used in negative existentials:

Ta mei chiguo Zhongguo fan. ‘He has never eaten Chinese food.’
Ta meiyi chun fan le. ‘He has not finished eating yet.’

As a remote perfect unmarked for deixis, guo also does duty for pluperfect. The placement of the time adverbial qu nian ‘last year’ indicates its scope:

Qu nian Zhangsan (yijing) qu-guo Xiang Gang. ‘Last year Zhangsan had (already) gone to Hong Kong.’
Zhangsan qu nian qu-guo Xiang Gong. ‘Zhang went last year to Hong Kong.’

Resultative zhe
According to Cohen (1989:128), zhe is etymologically related to zhu ‘stick, stay’. A gloss for zhe as an aspect seems to be ‘be in a state resulting from e’, i.e. it is a continuative perfect in e\r. It produces open event types out of activities, accomplishments, and in particular acquisitions (Jaxontov 1988:123). The subject of the form is the subject of the result state, i.e. zhe on transitive verbs appears passive.

Men shang xie-zhe sige zi. ‘Four characters are written on the door.’
Qiang shang gua-zhe ji zhang huar. ‘Several pictures are hanging from the wall.’
Ta zai chuang shang tang-zhe. ‘He lies on the bed.’
Women bici shen ai-zhe, bici yilai-zhe. ‘We deeply loved each other, and relied on each other.’

It is infelicitous of simple states:
Ta yixian chengzhi(-zhe). ‘He is always honest.’
Ta zhidao(-zhe) zhe ge huida. ‘He knows the answer.’


Huangpin puo(-zhe). ‘The vase has (still) shattered’.
Fangzi qi(-zhe). ‘The house has (still) been painted.’

These constraints fit the suggested paraphrase ‘be in a state’: there is a locative feel to the state. Zhe is a common source of existential sentences. Zhe appears with adjectives to indicate a temporary state:

Wo die bing-zhe ‘My father is ill’.

As a medial state, zhe cannot get an inceptive reading, which gives it a progressive feel. This cannot mean that Mary reddened as a result:

Zhangsan dasui menkou de boli de shihou, Mali lian hong-zhe. ‘When Zangshan broke the glass door, Mary’s face was (= had turned) red.’

Given its progressive form, zhe can be expected to frame other events:

Wo chi zhe fan nian shu. ‘I study while eating.’

Progressive zai

Chinese zai (related to the locative verb/preposition zai ‘(be) at/on’) seems a straightforward interior progressive (Smith 1991:117). It applies to extended dynamic event types (activities and accomplishments) and shuns simple event types (states and changes), where it coerces the event type to iteration:

Zhangsan zai kou men. ‘Zhangsan was knocking at the door.’

Zai contrasts with zhe in the following pair:

Zhuoz shang fang-zhe shu. ‘On the table lie some books’.
Shu fang zai zhuo shang. ‘The books are lying on the table.’

The distinction between zai and zhe is apparently disappearing. Zhe is taking over progressive uses of obsolescent zai,becoming an allaround imperfective marking. In this function, zhe produces progressive and generic states out of various event types, including activities. The rich class of acquisitions in Chinese provide a locus for neutralisation.

Wo lai de shihour, tamen zheng chi-zhe fan. ‘They were just having dinner when I came.’
Ni dangshi mi-zhe Makesi, Engesi, Liening. ‘At that time you were fascinated by Marx, Engels, and Lenin.’
Quan shije de ertong dou wan-zhe tong yang de youxi. ‘The world’s children all are (in the habit of) playing the same kinds of game.’

Reduplication

There is a lexicalised reduplicative aspect type called tentative reduplication which looks like a perfective of an iteration pf e ‘do e for a while’, producing a cycle of an activity. The appearance of a parenthetical yi ‘one’ in some cases suggests a cognate object construction ‘walk one walk’, which is cross-linguistically a common way to produce cycles out of activities.

Zheige wenti wo xuyao yanjiu yanjiu. ‘I need to research this problem for a while.’
Wo zou-(yi)-zou. ‘I walk a little’

According to Henne et al (1977) , this is a case of confluence of two etymologically unrelated constructions, reduplication and cognate object construction. (Cf. the supposed confluence of present participle and gerund in the etymology of English present progressive.)244

244A conjecture: reduplication can be formalised literally as iteration in whatever dimension is appropriate for each event type. (Henne et al. 1977: 133ff).
Object ba

Chinese allows, in addition to an unmarked SVO word order, an alternative order S ba O V where ba (originally 'take, hold, have', Li and Yip 1979) is a serial verb turned into an object case. Tenny (1994, cf. Cheng 1988) reports that ba is compatible with perfective and extended now le as well as the resultative zhe, but not with the progressive zai nor with states or cycles, including guo (Ritter/Rosen 2000):

*Ta zai ba Zhangsan sha. 'He is killing Zhangsan (prog).'
*Lisi ba Xiaoming kanjian-le. 'Lisi saw Xiaoming (pf).'
*Wo ba Lisi tui-le. 'I pushed Lisi (pf).
*Ta ba fangjian da-sao-le. 'He swept the room (pf).
*Zhangsan ba bing chi-guo. 'Zhangsan ate the cake once (pf res)

Ta ba che gei wo le. 'He has given the car to me (perf).
Lisi ba　daiy chuan-zhe. 'Lisi is wearing the coat (res).
Wo ba Lisi tui-dao-le. 'I pushed Lisi over (pf).
Ta ba fangjian da-sao de hen ganjing. 'He sweeped the room clean (pf).'
Zhangsan chi-guo bing le. 'Zhangsan has eaten cake once (pf res).

Ba is allowed where the object is 'effected', i.e. the subject of a change implied by the event: the car is mine, the coat is on Lisi, Lisi fell over, the room got clean. Li and Yip (1979) note that besides allowing the object before the (main) verb, ba also tends to turn it definite or specific, often possessive. This accords with ba's possessive etymology (Wo ba Lisi tui-dao-le 'I have Lisi pushed over') as well as with general word order principles (Carlson 1983). Like Finnish object cases, ba can mark the subject of existential or possessive intransitives with passive diathesis (often with an implied adversative beneficiary). All of this makes ba typologically resemble a possessive perfect.

Ba yusan gei diu le 'Their umbrella got lost.'
Ba ge zhu pao le. 'A pig ran away' (They had a pig run away on them).
Ba huzi dou bai le. 'His beard got all grey.' (He got his beard all grizzled).

Durative adverbials

Open event types bounded by a durative adverbial have perfective le. The temporally bounded occurrence of the activity is repeated to avoid a double object construction.

Ta shui jiao, shui-le yige zhoutou. 'He slept, he slept an hour.'
Wo deng ren deng le yige zhoutou le. 'I waited for somebody, waited an hour.'

An auxiliary verb construction not unlike the English spend t o e is used to measure accomplishments. According to Smith (1991:373), the construction does not allow achievements. But then fall asleep five minutes is out in English too.

Ta-men hua-le san nian gai-hao nei-ge jiao. 'They spent three years building that bridge.'
Shui-dao hua-le haizimen wufen zhong. 'Falling asleep took the children five minutes.'

Cong 'from' and dao 'to' are movement verbs ('follow', 'arrive') serialised into prepositions:

Women shangwu cong badian dao shiyidian ban shang ke. 'We attend classes from 8 to 11:30 in the morning.'

More languages

In this section, I take quick glimpses into more languages based on second hand descriptions, just so see whether my conceptual grid fits them.

Japanese

Japanese is a head-final language. Japanese postpositional case wa marks topic, ga subject, .o object, and ni indirect object.

Against these case assignments, Japanese rare is quite unusual for a passive. Indirect object becomes subject, subject becomes dative, object stays put.

Sensei wa Taroo o sikatta. 'The teacher scolded Taroo.'
Taroo wa sensei ni sikararetta. 'Taroo got scolded by the teacher.'
Okaasan wa kodomo o obaasan ni azuketa. The mother entrusted the child to the grandmother.
Obaasan wa okaasan ni kodomo o azukeraretta. 'The grandmother was entrusted with the child Tanaka-san wa sensei ni kodomo o sikararetta 'Tanaka had his child scolded by the teacher.'
Another peculiarity is rare manages to passivise some ditransitives, while it cannot do so for others:

Hanako wa Taroo ni eigo o osieta. 'Hanako taught English to Taroo.'
Taroo wa Hanako ni eigo o osierareta. 'Taroo was taught English by Hanako.'
Satoo-san wa Tanaka-san ni kuruma o utta. 'Sato sold a car to Tanaka.'
Tanaka-san wa Satoo-san ni kuruma o urareta. 'Tanaka was sold a car by Sato.'

Curiously, too, there is an adversative construction on rare for intransitive verbs. Here rare increases arity of event type instead of decreasing it.

Taroo wa ame ni hurareta. 'Tanoo had rain fall on him.'

All these peculiarities fall in place if the Japanese rare is not a passive at all but a submissive or adversative construction (Klaiman 1983, 1987, 1991). weak causative medial voice, meaning let x do p (to) oneself This analysis makes all the case assignments conform to semantic roles. The adversative use on intransitives is no longer a mystery. We also see why rare should prefer animate subjects another curious property for a passive (Howard et al. 1976:215).

Makino (1972) has observed that the following Japanese sentence is ambiguous about who is unwilling, unlike the English passive but like its abilitative paraphrase. This too is accounted for.

Hanako wa Taroo ni iyaiya syootai sareta. 'Hanako was unwillingly invited by Taroo/Hanako had Taroo invite him unwillingly.'

The much discussed reflexive pronoun zibun falls in line, given it is bound to a subject role not in its scope.

Japanese causative sase (Shibatani 1976, Howard et al. 1976, Manning et al. 1998) marks the subject of the effect as indirect or direct object depending on whether the subject of the effect is agentive.

Mitiko wa hon ga/o yomeru. 'Michiko can read the book.'
Mitiko ga Taroo ni Ziroo o yobaseta. 'Michiko made Taroo call Ziroo.'

The difference translates to y do x laugh ‘y causes x laugh unwillingly’ versus y cause x do x laugh.

This is a dative type causative, where the subject of the effect becomes an indirect object of the cause and the object of the effect stays put. The rare operator changes the roles of the two agents, not first agent and last object, as in a passive of a causative of passive. The case assignments again match the role assignments.

Mitiko ga Taroo ni Ziroo o yobaserareta. 'Taroo had Michiko make him call Ziroo.'

It has been observed that passive causative rare sase is necessitative, though rare alone can be abilitative (Howard et al. 1976:225). This follows from logic. One who lets another make him do something gets to do it.

Summing up, the difference between sase and rare is that rare is medial. This is nicely brought out by the minimal triple


Navajo

The Navajo language has a complex system of morphological aspect which according to Smith (1991) does not map onto the Vendlerian taxonomy in any straightforward way. It is therefore interesting to see if it matches the finer grid available to us. Here, my main sources are Smith (1991) and Younger/Morgan (1987).

Navajo is a polysynthetic language. Navajo verb morphology is ‘fiendishly complex’ (Smith 1991:393). Simplifying things, and mapping facts into more familiar terminology than traditional in Navajo grammar, the order of bound morphemes in a Navajo verb form, left to right, is preverbs, object pronoun, prefixes, subject pronoun, and verb.
preverbs in the outermost position are more or less loose adverbs and postpositions analogous to English adverbs and prepositions. The prefixes are tighter adverbial elements, including a number of aspectualisers, rather like English verb particles and prefixes *go on, re-do.*

A verb form like néédi *he eats it regularly* consists of preverb *ná* marking iteration, object pronoun *yi,* and verb *dyéih* *eat.* Comparing to English *(he) eats it regularly,* Navajo is the mirror image: *regularly-it-s-eat (he).*

The verb theme *dyéih* consists of a diathesis marker *d,* and a stem *yíih.* Simplifying again liberally, the *d* diathesis is reflexive, *lh* is causative, and *l* (apparently a combination *d+lh*) is medial (reflexive causative). In many cases the diathesis marker is lexicalised into the verb.

Preverbs too tend to be lexicalised with the verb, rather like English verb plus particle constructions, so combinations of preverb plus verb get listed in the dictionary as verb bases. As with English compound verbs, the inflections go in between the preverb and the theme. Example:

<table>
<thead>
<tr>
<th>stem</th>
<th>theme</th>
<th>base</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>kaad</em></td>
<td><em>‘spread (itr)’</em></td>
<td><em>lkaad ‘spread (tr)’</em></td>
</tr>
<tr>
<td><em>na...kaad ‘spread (tr) down’</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 64

States (called neuter verbs in Navajo grammar) get lexicalised out of all of the aspect types. Formally (and etymologically) many are perfectives or perfects (space-time metaphors in *ni,* postures in *si,*), others appear iterative or progressive (generic and temporary states).

Navajo reference grammar (Young/Morgan 1987) lists no less than 11 primary aspects with 10 subaspects (prefixal derivational aspects), which cross-cut with 7 grammatical modes (suffixal grammatical aspects and moods). This abundance comes from enumerating three layers of aspect morphology: preverbs, prefixes, and stem variants. Many etymologically related morphs have multiple roles as prefixes, preverbs and postpositions (not unlike, say, Greek, Russian, or German ones). A good guess is that all this involves more lexical derivation than the latinate names suggest.

The summary impression I get from a cursory acquaintance with Navajo reference grammar is that it over-grammaticalises a system which is largely lexically and morphologically governed. A more lexicalist, piecemeal verb-plus-particle approach could be more revealing than the current slot-filler tabulation method and terminology.

To show in detail how Navajo aspect fits my formalism, I ought to reshape the entire Navajo aspect system along more morphology-true lines, whereby the aspect type of a given form is determined by composing the inherent event type of the verb, the stem variant, and the aspect prefixes and preverbs tacked on it. It is too much to take on given the scant evidence I have, so I’ll just throw a sketch of the received view.

**Grammatical aspect**

The seven modes look like old suffixal aspects grammaticalised as inflections. They implement essentially four major grammatical aspects, plus future tense and optative mood, both unmarked for aspect.

The **imperfective** mode has no marker of its own (on open event types?). It produces an open event type, glossed ‘be in the process/act of Ving’. A perfective *ni* on an imperfective produces a point progressive ‘be about to’, reinforced by *k’adé–e– ‘almost’.* Perfect prefix *si* plus imperfective is odd (cf. *I am having Ved*).

The **perfective** mode describes an event as completed. Its marking, originally *yi,* can reduce to just a high tone. In practice, it is often equivalent to the English simple past tense. All the three aspect prefixes are common with the perfective. Stative prefix *si* plus perfective does duty for perfect in Navajo.

The **usitative** and **iterative** modes are often used interchangeably. The usitative is habitual. The iterative adds prefix *ná* to the usitative stem and expresses actual repetition. Terminative prefix *ni* is incompatible with these modes.

The **progressive** mode is an interior progressive specialised for comparative changes. It is marked out by a *yi* prefix on a distinctive stem.

The **future** mode is a combination of inceptive prefix *di* with progressive mode, lit. ‘be starting to’. Unlike the progressive, the future is primarily a tense. There are verbs which have future but no progressive. The future is also used for various futurate modalities (prediction, ability, obligation, want).

The **optative** mode is marked by the prefix *ő* on the imperfective stem. It has a range of uses typical of a bound futurate (subjunctive) form.

This gets us 16 paradigms of person inflection in all, combining five modes (imperfective, perfective, progressive, future, optative), four prefixes (-/ni/si/yii) in the imperfective and perfective modes, and intransitive/transitive diathesis *d/lh* in the perfective. (It just can’t look this complex to a Navajo!)
Aspect prefixes

Aspect prefixes in the prefix position are a grammaticalised system for three varieties of perfect(ive) aspect called completive, terminative, and stative. Completive is the name of the unmarked form, describing an event that ‘simply takes place’. Terminative ni ‘to’ is perfective: the event ‘takes place at a point of time’ and involves termination in the sense of ‘finish, stop, quit, arrive’. The stative si is resultative: it describes the object as ‘being placed in a position, in a state of rest’. The terminative and stative aspects are in opposition in *yas yilhtlh is/sêlhlh is ‘I made a snowball/I have made a snowball’, nédá/sédá ‘I sat down/I have sat down, sit’.

Further aspectualisers (called subaspects) can be stacked in front of aspect prefixes: di (‘at, in, on’) ‘start’, ni (‘to’) ‘stop, finish’. Aspectualiser ni is homophonous with the terminative ni, so there can be two ni’s in a row. The combination di+ni is continuative ‘keep on’; hi marks series ‘one after another’, ná means ‘back’, and náá(ná) ‘again’.(cf. iterative mode prefix above).

Examples of combinations: *dišaah ‘I am starting to go along’, *nishdaah ‘I am sitting down’, *náníshdááh ‘I am going back,’ háácha/hadínéscha ‘I started to cry/cried and cried’, *iíh hishtsee̞eh ‘I am putting them in one after another’, *taah náánshtéeéh ‘I put it into the water again’. I bet many are compositional, or have been so.

Derivational aspects

Stem sets for the grammatical modes, combined with aspectual prefixes and preverbs with rough class meanings, form what is called primary aspects in Navajo reference grammar. They are exemplified by rows in the following partial table for stem ‘a’ ‘move, roll’ (deviations from unmarked forms shaded):

<table>
<thead>
<tr>
<th>Aspect/Mode</th>
<th>Imperfective</th>
<th>Perfective</th>
<th>Usitative-iterative</th>
<th>Progressive-future</th>
<th>example (imperfective)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Momentaneous</td>
<td>‘aah’</td>
<td>‘á’</td>
<td>‘áah’</td>
<td>‘ááh’</td>
<td>*dišaah ‘I start to carry’</td>
</tr>
<tr>
<td>Transitional</td>
<td>‘aah’</td>
<td>‘á’</td>
<td>‘áah’</td>
<td>‘ááh’</td>
<td>*binti yií aah ‘he gets upset’</td>
</tr>
<tr>
<td>Continuative</td>
<td>‘á’</td>
<td>‘á’</td>
<td>‘áah’</td>
<td>‘ááh’</td>
<td>*naash’a ‘I carry around’</td>
</tr>
<tr>
<td>Repetitive</td>
<td>‘ááh’</td>
<td>‘á’</td>
<td>‘ááh’</td>
<td>‘ááh’</td>
<td>bésh ‘ááh ‘I rub it on’</td>
</tr>
</tbody>
</table>

Table 65

Not surprisingly, the least marked stem surfaces in aspectually matched (continuative imperfective or transitional perfective) combinations of aspect and mode. My guess is that the nasal element in the perfective is perfective and the long/high tone forms are imperfective (iterative and/or progressive).

Momentaneous is the misleading name of the aspectually least marked stem set. It is the most common and productive stem set in Navajo and the one used with most prefix and preverb aspects. It is aspectually transparent; the eventual event type depends on lexical event type, aspectual prefixes and grammatical aspect: imperfective *taah yifá ‘I got into the water’. Morphologically, it has most stem distinctions.

Transitional stem set is closed and produces inceptions. Marked with *yíí ‘away’ in prefix position, its stem set is the simplest of all.

Continuative stem set has the unmarked stem in the imperfective mode and gets marked in both perfective and iterative modes. Accompanied by preverb *na ‘around, about’, it accommodates open event types. Distributive preverb *da ‘severally’ and diverutive *taa ‘among’ produce closely related derived open event types.

Repetitive stem set matches the usitative-iterative mode. Reversative subaspect *ná ‘up, back’ based on the repetitive stem set can be open or closed. Semelfactive subaspect has *yíí plus repetitive aspect. It produces once-only cycles out of iterations.

The amount of redundancy in the table and the systematic nature of the deviations suggest that a decision tree based on morphological form might yield better insight than procrustean cross-tabulation. (Young/Morgan 1987 admit that stem variation in Navajo needs work.) Plausibly, primary aspects are a newer, prefixal, semantically semitransparent derivational layer while modes are an older, suffixal layer, grammaticalised into inflections.

Tenses

Navajo like Hopi divides time into marked future and unmarked nonfuture. Within nonfuture time, the aspect system expresses relative tense by the usual temporal defaults (imperfective is present, perfective past), which can be overridden using temporal adverbials *dooleelh ‘it will be’, *n’téé ‘it was’.

245 A dummy placeholder yi may appear for further prefixes to tag onto, but it makes no semantic contribution.

246 It may be mooted whether this way of reducing stem complexity is the most effective one.

247 Apparently, the unmarked stem is also historically closest to the Athapaskan roots.
The inceptive imperfective *dishádh* ‘I am in the act of starting to go’ expresses near future; the future mode is (more) remote. Conversely, the inceptive perfect describes plans in progress: *háágóoshá* *díníyá* ‘where have you started to go = where are you going?’, *bi niíthgái* ‘I finished starting to heat it = I’m heating it’ (Smith 1991:406).

Future past is expressed by perfective with *dooleelh*: *néinídzáago t’áá* ‘íidá á’ *iíyá á* *dooleelh* ‘when you get back I will already have eaten.’ Past future produces a conditional: *doo nahaltingogo hooghan bine’ji n’deeshbás n’i’éé* ‘if it did not rain I would park behind the hogan’; past conditional would have *dooleelh* *n’i’éé*.

**Time adverbials**

One way to express duration is analogous to English *A day passed while I was hoeing*; *náháshgodo shee* ‘i’i’i’a. The temporal subordinate clause denoting the event measured is simultaneous with the main clause that measures the time, hence the event must appear in the imperfective. Imperfective is also required with durative adverbials:

*tlhéé’* biíghah shilh oolwolhgo (*eelwodgo*) bimiinaa k’ad ch’ééh déyá. ‘After driving all night, I am tired now.’

Navajo perfective aspect is unable to scope over the durative adverbial, which reflects its lexical character compared to Romance perfectives.

**Conclusion**

My conjecture is that Navajo makes many of the same distinctions using much the same morphological devices than more familiar languages. The alien effect is at least partly due to an exoticising method of description that tries to box in derivational morphology into inflectional paradigms. Russian too has an impressive number of aspects when occasional meanings of prefixes are treated as grammatical categories with latinate names.

Smith (1991), operating with a two-component theory, is hard put to fit her division between situation types and viewpoints on Navajo. Her problem is that Navajo cuts events too finely. To arrive at a one-one match, Smith reconstructs situation types from arrays of related verb bases in Navajo. In my approach, Vendler’s fourfold is just one selection among event types definable from the calculus, and aspect devices can stack to more levels than just two. The distinctions overtly made in Navajo can then be reflected in it morphology—true as they are.

**Cree**

My belief is that in analysing a language, it is important to pay attention to the morphology. Failure to understand the morphology is apt to cause much mystification. Meanings will fall out if one finds suitable combinators for the meanings of the morphemes. Not that there is so many meanings of prefixes are treated as grammatical categories with latinate names.

The Cree language is spoken in many communities across north-central Alberta, Saskatchewan, and Manitoba, and in northern Ontario and Quebec, and they form a majority in the population of much of this area. Cree and related Algonquian languages are synthetic languages like Navajo. Cree verbs and nouns have much morphology in common.

*nitemína:nak nipéhána:nak. I horse I pl pl I wait I pl pl* ‘We are waiting for our horses.’

*ní-ta:ni:s-i-na:n-ak I daughter we pl ‘our daughters’*

*ní-sa:kíh-á:-na:n-ak I love we pl ‘We (not you) love it/them’*

Cree morphophonology: it can come from *e* or *i*. *t* can come from *t* or *th*. *h* before *k* or *t* can come from *m* or *n*. *ci* comes from *i*. *o*: *can come from *wi*. *a*: can come from *ae*. *e*: can come from *ai*. Word final short vowels and *w* can drop.

Cree nouns are grammatically sorted into animate and inanimate. A fourfield of event types it distinguished morphologically, transitive/intransitive versus animate/inanimate patient. Here are event types from simple to more complicated. Inanimate intransitives only have third person obviously. There is a lot of persons. Inclusive first person is glossed ‘you with us’. Obviative fourth person is glossed ‘other’. The left column lists indicative (independent) forms, the right column subjunctive (dependent) forms. The relative construction *e*: is just one of many uses of the latter.

*mihkwá: *-w red it ‘it is red’

*e:-mihkwá: *-k ‘such that it is red’

*mihkwá: -w-a red it pl they are red’

*e:-mihkwá: -ki

*mihkwá: -y-i red other it ‘the other is red’

*e:-thkwa: -yi

*mihkwá: -y-w-a red other it pl ‘the others are red’

*e:-mihkwá: -yi-k-i

Animate intransitives are infected thus:

*ni-pimipahta:-n I run ‘I run’

*e:-pimipahta:-y-a:n

*ki-pimipahta:-n you run ‘you run’

*e:-pimipahta:-yan
ni-pimipahta:-n-a:n I run we ‘we (not you) run’ e:-pimipahta:-y-a:h-k
ki-pimipahta:-n-a:n-a:w you run we ‘you run with us’ e:-pimipahta:-y-a-h-k
ki-pimipahta:-n-a:w-a:w you run you pl ‘you all run’ e:-pimipahta:-y-e-k
pimipahta:-w run he ‘he runs’ e:-pimipahta:-t
pimipahta:-y-i-w-a run other ‘the other one runs’ e:-pimipahta:-yi-t
pimipahta:-w-a:k run he pl ‘they run’ e:-pimipahta:-c-i-k

There is an indefinite subject impersonal passive that goes
pimipahta:-n-iw-iw ‘they (people) run’ e:-pimipahta:-hk

The two-place event type wap ‘see’ also has an animate intransitive inflection:

ni-wa:p-i-n I see ‘I (can) see’.
ki-wa:p-i you see ‘you (can) see’ etc.

Note that –in does not distinguish first and second person here. The (in)animacy of the second argument of a two-place event type is marked on the verb stems and endings. For instance wa:p-aht means ‘see something’ and wa:p-am ‘see somebody’. wa:p-aht number agrees number with the first argument. Word order is free. My guess is that am is the goal case of a demonstrative pronoun ‘this one’. It might also hide inside ah < am.

ni-wa:p-aht-e:-n mohkoman I see knife ‘I see a knife.’
ki-wa:p-aht-e:-n you see it ‘you see it’
ni-wa:p-aht-e:na:n I see it we ‘We (not you) see it’.
ki-wa:p-aht-e:-na:naw you see it we ‘You and we see it.’
ki-wa:p-aht-e:-naw you see it you pl ‘You all see it.’
wa:p-aht-am napew mohkoman man see it knife ‘The man sees a knife.’
wa:p-aht-am-wak napewak mohkoman man pl see it knife ‘The men see a knife.’
wa:p-aht-am-i-yi-w-a see it other ‘The other(s) see(s) it’

Animate object main clause direct forms go

ki-wa:p-am-i-n you see me ‘you see me’
ki-wa:p-am-i-n-a:n you see me we ‘you see us’
ki-wa:p-am-i-n-a:w-a:w you see me you pl ‘you all see me’
ni-wa:p-am-a:w atim I see dog ‘I see a dog’
ni-wa:p-am-a:n atim I see we dog ‘we (not you) see a dog’
ki-wa:p-am-a:w atim you see dog ‘you see a dog’
ki-wa:p-am-a:n-aw atim you see we dog ‘you and we see a dog’
ki-wa:p-am-a:w:aw atim you see you pl dog ‘you all see a dog’
ni-wa:p-am-a:w:ak sisip-ak I see pl duck ‘ducks are seen by me’
ki-wa:p-am-a:w:ak sisip-ak duck you see refl pl ‘ducks are seen by you’
wa:p-am-e:w nape:w atim-w-se man dog ‘a man sees a dog’
wa:p-am-e-w:ak sisip-ak napew-a see pl duck pl man ‘ducks see a man’
Experiential verbs like se:kih ‘frighten’ have inanimate subject inverse forms for first and second person.

ni-se:kih-iko-n I frighten inv 'I am seen by other'
frightened by it'
ki-se:kih-iko-n you frighten inv 'You are seen by other'
frightened by it
ni-se:kih-iko-n-a:n I frighten inv we 'We (not you) are seen by other'
frightened by it
ni-se:kih-iko-n-a:n-w you frighten inv 'You and we are seen by a dog'
frightened by it
ni-se:kih-iko-n-a:n-w-a:k you frighten inv other 'You and we are seen by a dog'
frightened by it
ni-se:kih-iko-n-a:n-w-a:k see other he 'I am seen by a dog'
There is a nonagentive passive that goes as follows. (Dahlstrom 1991:52).

Persons

Note that ki-w:ap-am-in ‘you see me’ and ki-wa:p-am-it-i-n ‘you are seen by me’ are only distinguished by the inverse marking. The fact that there is no way to say

ni-wa:p-am-? I see you ‘I see you’
ni-wa:p-am-it-i-? I see inv you ‘you see me’

has been read as evidence for 2 > 1 person ranking in Cree (Dahlstrom 1991:44). It does look like a case of ‘you first’ politeness.

But there is a morphological explanation too: it is difficult to say what the object form for ‘you’ should be. There is little evidence for first and second patient person pronouns in the main clause conjugation. Comparison to possessive forms suggests that suffixal persons mark subject, not object. From the dependent conjugation, one can conjecture – *en for a first person marking, second person could be – an. *wa is a common Algonquian third person pronoun. k marks plural.

The t are hard to figure out, the more so as they can have two sources. In the intransitive lot, it goes with third person. In animate direct, it goes with second or third, in the inverse, with first person. If there is only one t, the best bet is that it marks third person. What remains hard to fathom is subjunctive first-second direct wa:p-am-ak/t ‘I/you see him’ against inverse wa:-p-am-it/sk ‘he sees me/you’.

Compare also the intransitive inflection ni/ki-wa:p-in ‘I/you see’ where -in fails to distinguish first and second person, and the dependent conjugation forms e:wa:p-am-iy-an / e:wa:p-am-it-an, which also don’t mark patient. Here may be a case for pragmatics: patient person is not marked but inferred by elimination.

The only object pronoun candidates in the main conjugation are just the in(-a:n) in ki-wa:p-am-in ‘you see me’ and ki-wa:p-am-in-a:n ‘you see us’. They could be a back formation from the inverse.

Obviation

The obviative system can also be domesticated. Here are examples.

napew atimw-a wa:p-am-ew e:·sipwehte·-t man dog his-see when leave ‘The man leaving saw the dog.’
napew atimw-a wa:p-am-ew e:·sipwehte·-yi-t man dog his see when leave other ‘The man saw the dog leave.’
niwa:p-amaw napew o-tasam-a e:·osiha-t. I see man his snowshoe of self fix ‘I saw a man fix his snowshoe.’
wa:p-amew iskwe:w napewa otasam-iyi-w-a e:·osiha-yi-t. see john man of self his snowshoe other of self fix other ‘A woman saw a man fixing his snowshoe.’
o:hi napewa ka-nipah-a-yi-t o-w-i-kima-kani-iyi-wa itotaha:-w his this man his who kill his other his other wife other his take there ‘She took the man who had killed his wife to the place.’

What I see here is a third person demonstrative system a this ‘this’ versus i that ‘that’ turned into reflexive and irreflexive (“obviative”) pronouns self and obviate other. The key is possessive constructions.

o-kosis-a pimipahta·-yi-w-a his son of self run other he of self ‘His son runs.’
The pronoun o ‘his’ must be a possessive form of a. Then o-kosis-a is analysed as a head marked double possessive with a reflexive suffix, like Finnish hänen poika-nsa. The “obviative” a is a proximate or reflexive possessive suffix doubling on the predicate as an agreement marker.

In this story, the proximal possessive a marks the possession distal and oblique by marking its possessor proximal and subject. The fact that a only appears with third person subject gets explained as well—it is a third person possessive.

The real obviative is the distal or reflexive pronoun i < e ‘that’. Translated morpheme by morpheme, the example above would go ‘this one’s son, this one’s, that other one does, this one’s.

Cree plural nominative ak and a are in complementary distribution: In Finnish too nominative is marked only on the plural pojat. The possessive form poikansa could be nominative singular or plural, or genitive or accusative singular. Reflexive pronouns shun subject position as they need a subject to bind to.

The inanimate plural maskisin-a shoe of self could be a noncount partitive like French des chaussures of shoe.

**Case**

A further conjecture is that m is a goal case and kw a source case. The paradox that passive forms look like direct forms is explained (Dahlstrom 1991:52).

\[ \text{ni-sa:kih-i-k-a-w-in I love by other ‘I am loved’} \]
\[ \text{sakih-a-w love own he ‘he is loved’} \]
\[ \text{sa:kih-a-w-ak love own he pl ‘they are loved’} \]
\[ \text{sa:kih-i-m-a-w-a love to other own he ‘the other is loved’} \]

The object form *e-m of ‘that’ is found in

\[ \text{wa:p-am-e:-w o-kosis-a see her son of self ‘she saw her son’} \]
\[ \text{wa:p-am-im-e:-w o-kosis-iyi-w-a see other his son other of self ‘she saw his son’} \]

The inverse marking *e-kw comes to mean from other, for instance ki-wa:p-am-ik you see to this from other would match its meaning ‘this you are seen by that other’. I analyse the obviative pronoun yi as an irreflexive subject pronoun other.

Number agreement and oblique case marking are complementary. One plausible conjecture is that number agrees with subject, i.e. the plural marks a plural event type. Person marks direct voice agent and indirect voice patient. The obviative marking a appears on an animate oblique (object or agent) when there is a nominative subject. It appears in a possessive construction when possession and possessor are both animate. It is identical in form and in complementary distribution with inanimate plural. All this suggests to me that a is (originally) a third person possessive reflexive of self.

Doing morphology piecemeal bottom up, every bit of morphology does its own job. Each event type has its own roles. In ni-wa:p-am-ak sisisip-ak ducks are subject and I am agent, in ni-wa:p-am-akw-a-k sisisip-ak ducks are agent and subject and I am patient, in wa:p-am-ew-a-k sisisip-ak napew-a ducks are agent and subject and man is patient, in sisisip-ak napew-a wa:p-am-ikw-ak ducks are patient and subject and man is agent.

**Tense**

According to Neufeld (2002), ki: is placed before indicative verbs to make statements referring to past time. wi: (want) and ta: (will) are placed before indicative verbs to make statements referring to the future. Some speakers feel that ta is too definite to be applied to anything as unpredictable as the weather, as one person said, "Only God could say ta-nispon."

In Cree, the present tense can never refer to future time. wi:- or ta/-ka- must always be used with a verb referring to future time. On the other hand, Cree uses the present tense not only for something that is happening right now, but also for something that has just now happened. The past tense in Cree is used only for something that happened longer ago than just now. (ka is first or second person, ta third.)

\[ \text{ta-sipwe:hte:w ‘He will leave.’} \]
\[ \text{wa:pahke: wi:-sipwe:hte:w ‘He wants to leave tomorrow.’} \]
\[ \text{sipwe:hte:w ‘He (just now) left.’} \]
\[ \text{ki:sipwe:hte:w ‘He left (some time ago).’} \]

**Tagalog**

Tagalog (Schachter/Otanes 1972, McFarlane 1976, Kroeger 1993, Travis 2000) is a Philippine head-initial head-marking language with a bewildering array of diathesis operators.
Tagalog has different voices for object, instrument, location, and beneficiary marked in verb morphology. (This is not all that foreign to English, which can topicalise many roles with preposition stranding: I cooked the food, the food was cooked, the pan was cooked with, the kitchen was cooked in, you were cooked for.) The main difference is that the role is marked on the verb instead of the argument in for Tagalog.

<table>
<thead>
<tr>
<th>Tagalog</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kainan</td>
<td>Eat from this plate.</td>
</tr>
<tr>
<td>Kumain</td>
<td>Eat a banana.</td>
</tr>
</tbody>
</table>

English has only a few oblique transitives like inhabit ‘live in’, visit ‘go to’ and unmarked alternations like load cart with hay/load hay on cart.

On a closer look there is more method to the madness than first meets the eye. Before going into diathesis, the TA system can be tabulated as follows. On the right is a fourfield of forms: roughly, simple against open and nonpast against past.

<table>
<thead>
<tr>
<th>act</th>
<th>caus</th>
<th>pass</th>
<th>simple</th>
<th>reduplicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>-um-/</td>
<td>m-</td>
<td>-in</td>
<td>present</td>
<td>future</td>
</tr>
<tr>
<td>-um-</td>
<td>n-</td>
<td>-in-</td>
<td>perfective</td>
<td>imperfective</td>
</tr>
</tbody>
</table>

Elision and metathesis occurs under the pressure of open syllable structure, turning prefixes into infixes. There is an event nominal on pag with reduplication.

The exponents of the forms vary according to diathesis type as shown on the left. In active (intransitive) voice, -um- is infixed on all forms except future, clockwise: tumayo, tatayo, tumayo, tumatayo for tayo ‘stand’.

Active causative and reflexive voices mutate an initial p: makita, makikita, nakita, nakikita from kita ‘see’.

The direct passive of gamit ‘use’ goes gamitin, gaganitin, ginamit, ginagamit. The oblique passive of hawak ‘hold’ goes hawakan, hahawakan, hinawakan, hinahawakan.

Apparently, (i)n are event suffix (passive, past, resultative, perfective) markings, while (u)m and reduplication are event prefix (active, present, imperfective, progressive) markings. This jibes with markedness asymmetries in the exponency of forms (active is unmarked in the future and has no perfective).

Tagalog marks argument roles on verbs with voice affixes and nominals with prepositional cases. As in English, voice selects the nominal to act as subject and labels it semantic role on the verb. In Tagalog, the subject is marked with ang case. A direct argument is marked with ng case. Obliques get other cases, for instance sa ‘in/at/to’ (Musgrave 1998).

Voice is marked on the verb by affixes, some of which are lexicalised, some derivational, and some inflectional. A lexicalised affix makes a noncompositional contribution to meaning.

The voice affixes are part of the famous topic marking system of the language. Tagalog topicalises as freely as English passivises.

From bili ‘buy’ Tagalog gets bumili ‘buys’, makabili ‘can buy’, bilhin ‘is bought’, mabili ‘can be bought’, ibili ‘is bought to’, maibili, ‘can be bought to’, bilhan ‘is bought from’, pabilhin ‘is made to buy’, ipabili ‘is let to be bought’, mamili ‘shops’, mapamili ‘can be shopped’, magbili ‘sell’, ipagbili ‘is sold’, magpabili ‘can be sold’, pambili ‘buys (currency)’, ipambili ‘is bought with’. A longer stretch is found in makapagpatuloy ‘be able to continue something’ from tuloy ‘go on’. Here is a paradigm from Foley (1998):

<table>
<thead>
<tr>
<th>Tagalog</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>b-um-li</td>
<td>buy</td>
</tr>
<tr>
<td>ng isda</td>
<td>fish</td>
</tr>
<tr>
<td>sa</td>
<td>store</td>
</tr>
<tr>
<td>tindahan</td>
<td>man</td>
</tr>
<tr>
<td>ang</td>
<td>lalake</td>
</tr>
<tr>
<td>cause buy</td>
<td></td>
</tr>
<tr>
<td>‘The man bought fish in the store.’</td>
<td></td>
</tr>
<tr>
<td>bi-bilh-in</td>
<td>buy</td>
</tr>
<tr>
<td>ng lalake</td>
<td>man</td>
</tr>
<tr>
<td>sa</td>
<td>in</td>
</tr>
<tr>
<td>tindahan</td>
<td>store</td>
</tr>
<tr>
<td>ang</td>
<td>fish</td>
</tr>
<tr>
<td>isda</td>
<td>lalake</td>
</tr>
<tr>
<td>pass &quot;buy&quot;</td>
<td></td>
</tr>
<tr>
<td>‘The fish will be bought by the man.’</td>
<td></td>
</tr>
<tr>
<td>bi-bilh-an</td>
<td>buy</td>
</tr>
<tr>
<td>ng lalake</td>
<td>man</td>
</tr>
<tr>
<td>ng</td>
<td>in</td>
</tr>
<tr>
<td>isda</td>
<td>store</td>
</tr>
<tr>
<td>ang</td>
<td>fish</td>
</tr>
<tr>
<td>tindahan</td>
<td>lalake</td>
</tr>
<tr>
<td>pass cause</td>
<td></td>
</tr>
<tr>
<td>‘The store will be used to buy the fish in’</td>
<td></td>
</tr>
<tr>
<td>ipam-bi-</td>
<td>buy</td>
</tr>
<tr>
<td>ng lalake</td>
<td>man</td>
</tr>
<tr>
<td>ng</td>
<td>fish</td>
</tr>
<tr>
<td>isda</td>
<td>money</td>
</tr>
<tr>
<td>ang</td>
<td>salapi</td>
</tr>
<tr>
<td>inv buy</td>
<td></td>
</tr>
</tbody>
</table>
‘The money will be used to buy the the fish with.

\begin{tabular}{llllll}
   i-bi-bili & ng & lalake & ng & isda & ang & bata \\
\end{tabular}

‘The child will be bought a fish by the man.’

Tagalog diathesis morphology is quite expressive. For instance, Tagalog has a factitive passive, \textit{.ipatawag} (\textit{pass cause pass cause call}), like Finnish \textit{hänet kutsutettiin sisään} ‘he was ordered to be called in’, which is hard to convey in English.

Locative complements can be topicalised, as \textit{in katagpuan} ‘be (the place something is) found in’ from \textit{tagpo} ‘find’. This type is restricted to clefts and relatives, just like its English counterpart \textit{That box (is the one) I found it in}. On the other hand, Tagalog benefactive focus need not be counted as a separate diathesis, but a passive of a dative alternation.

The following operator assignments appear to account for a large share of the diathesis combinatorics in Tagalog. The event type provides possible etyma for the morphemes.

\begin{tabular}{lll}
   morph & diathesis & event type \\
   -um- & act & x in c: c cause e \\
   -ka- & be in & x in p \\
   -i- & pass & x: _ cause x p \\
   -pa- & refl let & become \\
   -pang & refl & y: x become p by y for \\
   & cause & z \\
   -pag- & cause & y: x become p by y \\
\end{tabular}

Recall that by definition, antipassive \textit{act} is agentive, \textit{refl let} is unergative and \textit{pass} is unaccusative. Tagalog causatives are dually vague between necessitative and ablative senses (make/let,enable). \textit{Pa}, in particular, comes close to a modal particle ‘be able/happen to V’. It will turn out that passive is the unmarked lexical voice in Tagalog.

\textbf{Voice combinatorics}


\textit{Ka} on its own seems an active intransitive stative participle \textit{be in}, as shown by event nominals \textit{pagkatalo} ‘to be frightened’ from \textit{takot} ‘afraid’ (cf. \textit{matalo} ‘become frightened’), \textit{pagkatalo} ‘to be defeated’ from \textit{talo} ‘defeat’ (cf \textit{matalo} ‘get defeated’). It also produces adjectives like \textit{kasunod} ‘next (i.e. following)’ from \textit{sunod} ‘follow’.

Medial (reflexive weak causative) \textit{refl let} \textit{pa} ‘become, get (by oneself)’ is a weak causative reflex of \textit{become} like English \textit{get}: \textit{madama} ‘is felt’ from \textit{dama} ‘feel (emotion)’, \textit{pasama} ‘let oneself be accompanied’ from \textit{sama} ‘be together’ \textit{madala} ‘can get carried’ from \textit{dala} ‘carry’, \textit{magawa} ‘can get made’ from \textit{gawa} ‘do, make’, \textit{matiyak} ‘can be ascertained’ form \textit{tiyak} ‘sure’. \textit{Pa} is the only prefix for a number of animate change verbs like \textit{maawa} ‘have pity’, \textit{mabahaw} ‘be healed’, \textit{mahilo} ‘become dizzy’ (Drossard 1994). Remember that adversative \textit{x let p} equals passive \textit{nx cause p} by the zero-sum game duality.

\textit{Pa} is one-place, so combination \textit{pa-pag} must logically sandwich another passive in between. For instance: \textit{pa-pag-akap-in} ‘be made to embrace one another’, \textit{pa(pagakap)in} from \textit{akap} ‘embrace’, \textit{mapaglagnyan} ‘can get placed on’ \textit{pa(paglagay)an} \textit{refl let pass inv cause become on} from \textit{paglagyan} ‘be placed on’, \textit{pa-pag-ka-galit-in} ‘be made to quarrel with one another’ \textit{pa((pagkagalit)in)}

There is no *\textit{mapaglagnya} or *\textit{magpapagsama} (Travis 2000:161). There is no \textit{pag-pag} either. These constraints follow from an analysis of factitive as causative of passive.

\textit{Pa} applies productively enough to become an aptative mood on its own right. For instance \textit{pa-ipang-basa} ‘be apt to be read with’ cf. \textit{ipang-basa} ‘be used to read with’ Compare also \textit{pa-i-pang-pa} in Drossard (1994) meaning ‘I was able to build myself a house with the money’.

\textbf{refl let pass refl cause refl let build me house money}

‘The money let itself be used to build me a house.’

Active intransitive \textit{pa-ka- refl let be} ‘let oneself be’ is a productive modal prefix, with weak reflexive causative meaning ‘be able/happen’. E.g \textit{alis} ‘depart’, \textit{makaalis} ‘be able, happen to leave’. Witness contrasts \textit{makaumawa} ‘be able to understand’ vs. \textit{umunawa} ‘try to understand’, \textit{malabas} ‘can go out’ vs. \textit{mailabas} ‘can be taken out’ vs. \textit{malabas} ‘happens to go out’, and \textit{makuwi} ‘can return home’ vs. \textit{mauwi} ‘happens to return home’.
Weak reflexive factitive *pa-pa refl let refl let* is found in mapasama ‘be able to be made to be together’ from sama ‘be together’, mapapunta ‘be able to be made to go to’ from punta ‘go to’. Mapalalit, malalipit and lumapit all mean ‘get close’, probably with different nuances of volition and success. mapabaliit ‘happen to be made to return’.

Passive resultative *i-ka pass be* is an inanimate or instrument causative ‘be what something is Ved by’, as in ikasira ‘be the cause of breaking’ from kasira ‘be broken’, ikabalik ‘be the cause of returning’. This double inversion type includes many emotion causatives.

Passive factitive *i-pa pass refl let* was already mentioned: pakain means ‘become eaten’ and ipakain ‘be fed to someone’ from kain ‘eat’, ipabigay ‘be let to be given’ from bigay ‘give’, ipagawa ‘be let to be done’. I construe the benefactive na-i-pa.gawa ‘get a house built for one’ as the passive factitive of the dative alternation ‘build someone a house/build a house for someone’, i.e. ‘be able to let oneself be built a house’.

Aptative inverse passive *pa-i refl pass inv* is found in maituro ‘can be taught’, maituruan ‘can be taught to’, cf tiuro ‘be taught’, turuan ‘be taught to’, mabiligay, mabigyan ‘can be given (to)’, cf. ibigay, bigyan ‘be given (to)’.

Active causative *pag cause* is a common way to form active transitive verbs. Typical transitive examples are malinis ‘get clean’, maglinis ‘cleanse’. transitive pagdalaan ‘pass’, intransitive dumasun ‘pass by’. Plural pag can be reflexive or reciprocal: magsama means ‘make themselves/each other be together’, magusap ‘converse’.

Passive causative *i-pag pass cause* is a straightforward transitive passive: ipagbili ‘be bought’ from bili ‘buy’.

Factitive *pag-pa cause refl let* is exemplified in the series from intransitive sunod ‘follow, obey’: sumunod ‘follows’, masunod ‘gets followed’, magpasunod ‘makes to be followed’. magparaan ‘makes pass’, magpalinis ‘makes to get cleansed’.

Passive of factitive *i-pag-pa pass cause refl let* is found in ipagpatuloy ‘be continued’ from tuloy ‘go on’.

*Pag-ka cause be* is reciprocal pa in mag-ka-inggit ‘envy each other’ or mag-ka-galit ‘quarrel’, compare ma-galit ‘be angry’, ma-inggit ‘be envious’. magkasa ‘be companions’, magkausap ‘converse’. The idea is converse from English: to cause envy reciprocally is to feel it reciprocally. Drossard (1994) reports an accent difference between magka-i-akap ‘be in embracing position’ and magkasyakap ‘happen to embrace one another’

Pag also forms active verbal nominal (gerunds) to denote event tokens, e.g. Mabilis ang pagdaraan ng mga araw. ‘Fast, the passing of many days.’ Generic open event types are denoted by case-marked base forms, e.g. Mahirap ang humanap ng trabaho ‘Difficult, the searching of work’.

Reflexive or medial *pang refl cause* alone produces unaccusatives like pangyari ‘happen’, i.e. be brought about by itself. Compare also causative pang-alaga ‘take care of’ with medial pang-alaga-an ‘care for’. from alaga ‘care’.

So called instrumental focus *i-pang as in ipambili ‘be used to buy with’ from bili ‘buy’ or ipangbasa ‘be used to read with’ from basa ‘read’, becomes pass refl cause _ This unpacks to be x: y cause x cause y ‘be what someone (ca)uses to cause something’. In my analysis, this is a composition of the usual passive.

There are two inflectional suffixal voices:

- **-in/-an**
  - **pass** ‘be Ved’
  - **pass inv** ‘be Ved at’

-in is a direct passive *pass* of a transitive event type. Examples of transitive active-passive pairs: manggalit ‘make angry’, galitin ‘get angry’ magsabi ‘say’ sabihin ‘be said’. Ditransitives allow two passives, direct passive bilhin ‘be bought’ and indirect ibili ‘be bought (to)’. Compare also ipagbili ‘be sold’.

-an is an oblique passive *pass inv* for directional complement verbs. halik ‘kiss’ halikan ‘be kissed’, bukas ‘open’ buksan ‘be opened’, alaga-an ‘be taken care of’. Compare gumamit ‘use’ gamitin ‘be used’, gamitan ‘be used on’, tumawag ‘call’, tawagin ‘be called’, tawagan ‘be called to’.

The oblique can be a location. uminom ‘drink’, inumin ‘be drunk’, inuman ‘be drunk in’, magturo ‘teach’, turuan ‘learn (be taught to)’, pagturo ‘be taught at’. Pag-an *pass inv cause* topicalises a location out of a transitive in paglayagan ‘be (where something is) placed at’, cf maclayag ‘place’. The location can only be the subject of a cleft or relative. This is no surprise as the lower clause already has its subject reserved by pag. Compare masaral ‘study’, pagaralan ‘be studied’, which has no competing subject.

Ito ang babong paaralan pinagtuturuan nya ng matematika. ‘This (is) the new school, taught math in by her’.

*Pinagtuturuan niya ng matematika ang bagong paaralan. ‘Taught math by her, (is) the new school.*

Plural subject *-an* can be reciprocal (plural reflexive). Examples: sumama ‘join’, sumahan ‘be joined’, tumulong ‘help’, tulungan ‘be helped’, magtulungan ‘help each other’ (cf sw hjälpas åt ‘help each other’, följas åt ‘follow one another’):

Naghahalikan si Pedro at si Maria ‘Pedro and Maria kissed (one another)’.
A locative oblique reciprocal is available for intransitives too: *pag-iyakan* can mean ‘cry together’, *pag-ka-dating-an* ‘arrive together’, i.e. cry, arrive with one another. No special dispensation is needed for this usage given the present analysis.

Interestingly, there is no specific reciprocal reading for benefactive or instrumental focus (Drossard 1994:14). I have suggested that benefactive and instrumental focus are epiphenomena of the passive, which has no reciprocal (cf *they were loved by each other*). It is possible to passivise an oblique reciprocal:

Nagaway si Ben at si Eddie dahil sa laruan. ‘Ben and Eddie fought about the toy.’
I-p-in-ag-away ni Ben at ni Eddie ang laruan. ‘The toy was fought about by Ben and Eddie.’

An oblique passive resultative *ka-an pass inv res* is found in *kinaawan* ‘be felt pity for’ from *awa* ‘pity’.

**Pa-an let refl pass inv** allows locative inversion between *pa-tuto* ‘learn’ and *pa-tutuh-an* ‘get taught to someone’, *pabilihan* ‘get to be where something is bought’. It becomes adversative ‘get Ved at’ on intransitives. Note how role and case markings are interdefinable here.

Namatay ni Hwan ang. tatau. ‘Happened to die on John the father.’
Namatayan ng tatay si Hwan. ‘Happened to die-on John the father.’

There is more derivational morphology and less grammar in Tagalog than in English. Diathesis prefixes are lexically governed. The suffixes are more productive and predictable. For instance, intransitive *hanap* ‘look for’ has object passive *hanapin* ‘be sought’, while *ihanap* is oblique passive ‘be sought for’ as in ‘I was sought a place to live’.

Intransitive *sama* ‘be together’ forms a causative passive *isama* ‘be made to be together’, a passive reflexive causative *pasama* ‘let oneself be together’ and an oblique passive *samahan* ‘be, get accompanied’, and *pagsamahin* ‘be made to be together, be mixed (pl)’.

Here is a tabulation of combinations and their combinatorial analysis.

<table>
<thead>
<tr>
<th><strong>bili</strong> ‘buy’, <strong>matay</strong> ‘kill’</th>
<th><strong>morphology</strong></th>
<th><strong>semantics</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>bumili</strong> ‘buys’, <strong>pumatay</strong> ‘killed’</td>
<td>um</td>
<td>ipf</td>
</tr>
<tr>
<td><strong>makabili</strong> ‘can buy’, <strong>makapatay</strong> ‘can kill’</td>
<td>ma ka bili, ma ka patay</td>
<td>refl cause res</td>
</tr>
<tr>
<td><strong>bilhin</strong> ‘is bought’, <strong>patayin</strong> ‘is killed’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>mabili</strong> ‘can be bought’, <strong>mapatay</strong> ‘can be killed’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ibili</strong> ‘is bought to’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>maibili</strong>, ‘can be bought to’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>bilhan</strong> ‘is bought from’, <strong>kamatayan</strong> ‘is died on’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pabilhin</strong> ‘is made to buy’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ipabili</strong> ‘is caused to be bought’, <strong>ipapatay</strong> ‘is caused to be killed’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>mamili</strong> ‘shops’, <strong>mamatay</strong> ‘dies’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>mapamili</strong> ‘can be shopped’, <strong>magbili</strong> ‘sells’, <strong>magpatay</strong> ‘kill’</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ipagbili</strong> ‘is sold’, <strong>maipagbili</strong> ‘can be sold’, <strong>pambili</strong> ‘buys (currency)’, <strong>ipambili</strong> ‘is used to buy with’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

My reconstruction of Tagalog makes *pa*, a weak causal reflexive *become*, the centerpiece. Causative *pag* is *become by*, containing *pa* and a trace of the genitive case *ng*. I conjecture that *(n)g, ng and ang* are all etymologically forms of one and the same subject case, the fuller form *ang* specialised for subject case. *Fang is pa* with the subject marking, which becomes reflexive or medial *become self*.
This reconstruction not only explains the morphological analogies, but also the curious fact that Tagalog places (nonpronominal) subject at the end of the sentence and marks it with case – both nonsubject-like properties. The word order matches the English the destruction of the city by the enemy.

**Event nominals**

The reconstruction also explains how come apparent causative pag doubles as a event nominaliser. For the reconstruction makes pa an exponent of a verb for be(come), i.e. an abstraction operator. If my analysis is correct, pa is far from being a mysterious intervening morpheme or disappearing particle as it remains in Travis (2000). Compositional morphology seems to allow better insight here than boxing forms into paradigms. The alternation paradigms described in e.g. McFarlane (1976:32ff) reflect lexical diathesis of the verbs for which the observed alternations make sense.

Tagalog moves freely between nominals and verbs. In nominals, pa is a deverbal object nominaliser what (is Ved), pang an instrumental nominal what (is Ved) with, pag a genitive or subject nominal whose (Ving), an a locative one where (it is Ved). This perspective fits the facts too: there are nominals answering these descriptions.

Under the nominal perspective, gerund pagdaraan can be glossed as *(pa-)n-g-da-duan (ng mga araw) as ‘their getting repeatedly passed (of many days)’. From from kausap ‘converse, interlocutor’ we get nominals like usapan ‘where it is conversed, conversation’, pangungusap ‘what is conversed with, sentence’. From tawag ‘name, call’ katawagan ‘what one is called by, title’, from tanaw ‘view’ tanawin ‘what one views, view’.

Take tanawin for instance. As a verb, it means ‘is viewed’. As a nominal, it means ‘what is viewed’, a view. The event types are equivalent, and are just one lambda conversion away:

\[
\begin{align*}
\text{view} & \quad \text{it} & \quad \text{it is viewed} \\
\text{view} & \quad \text{q} & \quad \text{it is what is viewed}
\end{align*}
\]

From this distance, then, the difference between the finite event and the event nominal is one of focus or perspective. The first one speaks about the event, the second about the object. Literally.

**Tamil**

Klaiman (1991) pursues a notion of basic voice defined by semantic features rather than argument structure. A basic voice like the middle need not add or reduce argument places in an event type. In his analysis, Tamil “weak” voice is an instance of a middle voice.

Evaluation of Klaiman’s analysis of voice in Tamil (a Dravidian language of South India) is complicated by the lack of attention to Tamil morphology in Klaiman (1991). What I say here remains therefore conjectural. On the other hand, if the conjectures are borne out, that is in itself an argument for bottom up typology.

A causative analysis of Tamil voice has been considered (Paramasivan 1979, Klaiman 1991:72), but rejected on account of examples like

\[
\begin{align*}
\text{kuzantai kal-ai utai-kir-atu child leg acc kick pres sg m} & \quad \text{‘The child is kicking with its legs.’} \\
\text{kuzantai enn-ai utai-k-kir-atu child I acc kick strong pres} & \quad \text{‘The child is kicking me’} \\
\text{avan tan kal-ai utai-t-t-an (*utai-n-t-an) he own leg acc kick strong past sg m} & \quad \text{‘He kicked his own leg.’}
\end{align*}
\]

It is not obvious that this is a counterexample for a causative analysis. The first example describes body motion. Note the English with which reveals the underlying role of the leg as the means, not the goal of the kick. The second example is its causative, meaning the child causes himself (his leg) to kick me. If the leg were mentioned here, I bet it would be in instrument case. The third example is a straightforward (double) causative ‘He caused his leg kick his (other) leg’.

Judging from examples, the weak-strong (“self-act” versus “other-act”) voice distinction in Tamil (Klaiman 1991) might very well involve causative and factitive morphology. Intransitive strong forms are unaccusative, weak forms are inergative or medial (oblique reflexive causative), while transitive strong forms carry an extra causative morpheme /h/.

Looking at morphological markings, it does look like the “strong” voice is the marked one.

\[
\begin{align*}
\text{pul matt-inal mey-ap pat-t-atu grass cow ins graze inf happen past sg n} & \quad \text{‘The grass was grazed on by the cow.’} \\
\text{matu pull-ai mey-n-t-atu cow grass acc graze weak past sg n} & \quad \text{‘The cow grazed on the grass.’} \\
\text{avan matt-ai mey-t-t-an he cow acc graze strong past sg m} & \quad \text{‘He grazed the cow.’}
\end{align*}
\]

The first example has neither “weak” nor “strong” morphology on it. It seems to say that some grazing happened by the cow. The second example has one t in it and makes the cow the subject. I take this to be a causative of the first one. The

---

248Dictionary equivalents for be in Tagalog are ay, maging and bagay. Ay forms a cleft where subject comes first. Have is translated as may.
role of $n$ remains open, it could be a reflexive marking. The third one has a double $t$ and makes the crow an object and adds a new subject. This looks like a double causative, or factitive. Another triple is slightly different.

puli avan-al vanank-ap pat-t-attu tiger he ins submit inf happen past sg n ‘The tiger was worshipped by him.’
aval katavul-al vanank-in-al she god acc submit past sg fem ‘She worshipped the god.’
avan puliyai vanak-k-in-an he tiger acc submit strong past sg m ‘He subjugated the tiger.’

Here the first two examples don’t have any voice marking (unless the $n$ is one), while the third example has a $k$ which could very well be an assimilated $t$. I submit that the verb *vanantu* ‘submit’ is not transitive, but an oblique reflexive ‘submit oneself to something’. This approach also seems to make sense of another puzzling minimal pair:

kuttam aval-ai neruk-in-atu crowd she acc approach past sg n ‘The crowd approached her.’
kuttam aval-ai neruk-k-in-atu crowd she acc approach strong past sg n ‘The crowd pushed in on her.’

I take *neru(n)k* to be a (again perhaps medial) motion verb ‘come nearer’. The first sentence thus means ‘the crowd came close to her’. The second sentence is an agentive (reflexive causative) transform of that, meaning ‘the crowd got (themselves) close to her.’ The net difference in meaning is ‘deponency’, i.e. planning and control. I take the ‘strong’ morphology to mark the motion as intentional. The meaning of unmarked ‘weak’ forms falls out by default. (Here my story differs from Klaiman, who considers ‘weak’ forms marked. Actually, both can be marked in places.)

In principle, there is no conflict of content between Paramasivam’s and Klaiman’s feature based approaches and the above analysis. The difference concerns the choice of primitives.

**Creoles**

Givón (1982) suggests that creole languages might reveal universal tense and aspect distinctions in barest outline. The following parallel paradigms of Nigerian English based pidgin and the Guadaloupe French creole (Raible 1990) are prototypical.

<table>
<thead>
<tr>
<th>Nigeria</th>
<th>English</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$  $M$  $A$  $V$</td>
<td>$T$  $M$  $A$  $V$</td>
<td>$T$  $M$  $A$  $V$</td>
</tr>
<tr>
<td>$i$</td>
<td>$t$</td>
<td>māżhe</td>
</tr>
<tr>
<td>bin</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>go</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>de</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>bin</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>bin</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>go</td>
<td>$i$</td>
<td>$t$</td>
</tr>
<tr>
<td>bin</td>
<td>$i$</td>
<td>$t$</td>
</tr>
</tbody>
</table>

Table 66

There is one tense, mood, and aspect marker each in this order (*bin*, $go$, and *stay* in Hawaiian Creole, Bickerton 1975). The tense is anterior, the mood is future, and the aspect is progressive. The simple form of a closed event type is perfective, that of an open event type is imperfective. Indexical tense is not marked; present, past and future narratives can all use the simple form. For open event types, the unmarked reference of the simple tense is present, for closed ones, it is nonpresent. For closed event types, the anterior tense is a relative past which places an event before events told earlier in narration. Past future is also used for counterfactuals.

Creole aspect (Raible 1990) instantiates universal defaults in barest outline. In Martinique Creole, the unmarked verb form is perfective for closed event types and imperfective for open ones. A change verb like *arriver* ‘arrive’ in the simple (perfective) aspect *i rive* ‘s/he arrived’ acts as a past tense. The present tense is expressed by an imperfective particle *i ka rive* ‘s/he is arriving’, while adding the past auxiliary *te* ‘was’ forms a pluperfect *i te rive* ‘He had arrived’. States (acquisitions) work differently: *tini* ‘have’ is a present tense *i tini 50 à* ‘s/he is 50 years old’, and *i te tini 50 à* ‘s/he was 50 years old’ a simple past. Logically, there is of course little difference between *i rive* and *i tini*, between *he arrived/he is there* and *he got/he has*.

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Klaiman (1991:106) notes a markedness asymmetry: in Indo-European where middle is marked, there are more active-only verbs, while in Tamil, there are more weak-only verbs. As I would expect.
Givón (1982), following Bickerton (1975), concludes that the Creole system derives from three markedness oppositions in sequence/anterior, closed/open, and realis/irrealis, matching the dimensions of temporal order, constituency, and factuality of events. The order of the elements reflects the relative scope of the operators. I just make this more concrete by identifying the three distinctions with perf, ipf, and fut, respectively.

The resemblance to the English paradigm is striking. The main difference is that English further splits anterior T into indexical past tense T and perfect phase P (placed between M and A).

An even simpler system without perfect is reported in Givón (1982) for Chuave.

Thai

The use of serial verbs pay ‘go’, maa ‘come’, and hay ‘give in’ Thai (Rangkupan 1992,1997) lends particularly iconic support for my event calculus. A striking feature is the variety of syntactic roles these verbs seem to take. They work across event and object domains, expressing tense, aspect, and diathesis over and above their prototypical meanings with uncanny predictability.

I start from everyday examples of coming and going:

```
khaw5 pay1/maa1 roong1rien1
he go|come school
‘He went/came to school’.
khaw5 deen pay1/maa1.
he walk go|come
he take book go
‘He walked away/toward me. He took the book away/along.’
khaw5 ?au1 nag5si5 pay1. chan5 ?aw1 burii2 maa1
he take book go
I take cigarette come
‘He took the book away/along. I brought cigarettes.’
khaw5 deen pay1/maa1 roongrien1. ?a21 khoong5 maa1 thii3 baan34
he walk go|come school take thing come at house
‘He walked to school/He came to school walking. Bring the things home.’
```

From a Western point of view, maa1/pay1 look like finite transitive verbs in the first case and directional prepositions or adverbs in the other two (Clark 1978). From the event calculus point of view, Thai serial verbs can be what the name says: event types concatenated in a causal chain. All the uses reduce to the same event type

\[ x \text{ m cause } \neg x \text{ in } p.x \text{ in } p \]

The difference between the transitive go school and the intransitive go to school is a difference about coding argument structure. The former is represented by \( \neg \text{in } p.\text{in } p \text{ }\langle \text{school} \rangle \) where the position of the goal is iconic. In the second, the sense of the motion is coded twice: \( \langle \neg \text{in } p. \text{ in } p \rangle \langle \neg \text{in } \text{school}. \text{ in } \text{school} \rangle \). The advantage of the redundant coding is that it commutes – word order is free. Notice that this explanation trades on the fact that the event calculus allows superposition of events as well as event composition.

The main verb use of go is obtained by leaving the means m unspecified, in which case pay can denote the entire event type. The serial verb use is obtained by instantiating the means to walk or take, in which case pay must denote the effect \( \neg x \text{ in } p.x \text{ in } p \). This we know is a denotational variant of the goal case to, represented by \( \neg x \text{ in } p'x \text{ in } p \). The goal p entails here for maa1 and \( \neg \text{here} \) ‘away’ for pay1.

It is striking how often the words go, to and away appear in English glosses of maa1/pay1. Consider for instance more abstract uses of pay1 and maa1 where the coming and going concerns less concrete changes.

```
khaw5 fan5 pay1
he dream|die go
‘He died away/went into a dream’.
book2 maa1 na?4
tell come please
‘Come on, tell me.’
khaw5 thoo1ra14sap2 maa1 baan3
he phone come home
‘He phoned me at home.’
```
Maa1 ‘come’ often glosses in English as to me (Rangkupan 1992:4) and pay1 ‘go’ as (away) from me. An instance of Thai avoidance of first person, a strategy of polite self-effacement no doubt.

Rangkupan (1992) gives a careful study of what it is that comes and goes in Thai. To make a long story short, the subject of come|go is the subject of the result of the event type. For instance, in the above examples, it is the subject in the first case and a signal or message in the other two which involve a causative communication verb. A more curious case is give:

\[\text{son5 daay3 ngeen1dian1 maa1 caak2 thaw3kee2} \]
\[\text{Son get salary come from boss} \]
\[\text{‘Son got his salary from the boss.’} \]

\[\text{thaw3kee2 hay3 ngeen1dian1 son5 maa1/pay1} \]
\[\text{boss give salary Son come|go} \]
\[\text{‘The boss paid Son his salary / paid off Son’s salary.’} \]

The shades of meaning are as one would expect if the salary is what goes from the source of the causal chain (the boss) and comes to its goal (Son). What is a small surprise is the word order in the last sentence. Why not boss give salary come|go Son in analogy with

\[\text{book2 mee3 pay1 si?2 nam4khaang4} \]
\[\text{tell mother go prt Namkhaang} \]
\[\text{‘Tell it to Namkhaang, Mom.’} \]

The word order makes sense if what is is coming or going is not just the salary but the entire event type. This would make Thai come and go not unlike the dativus commodi and in commodi of classical grammar (Kaegi 1970:§153, Kühner 1889:§423:17).\(^{250}\) There are other examples where entire event types seem related by come|go in Thai.

\[\text{dek2chaay1?iit4 ?iam3 (mii3) maa1 ding1 thung5phaa3} \]
\[\text{Iit reach hand? come seize fabric bag} \]
\[\text{‘Iit reached out (his hand) to pull away the fabric bag.’} \]

The net effect of maa1 here is close to a consecutive or final connective (so as to). The goal of maa1 is an event type, so the thought is not far to construe its subject in the same way.

Thai pay1 and maa1 mark aspect in the following uses.

\[\text{su?2rii1, tham1 kaan1baan3 pay1} \]
\[\text{Surii do homework go} \]
\[\text{‘Surii, go on doing your homework’} \]

\[\text{kee1 leey1 ngiap2 pay1} \]
\[\text{she then quiet go} \]
\[\text{‘She went quiet then.’} \]

\[\text{su?2rii tat2 phom5 maa1} \]
\[\text{Surii cut hair come} \]
\[\text{‘Surii has just cut her hair.’} \]

\[\text{khaw5 yiin1 maa1 naan1 dooy1 may1 phuut3may3caa1} \]
\[\text{he stand come long time without saying anything} \]
\[\text{‘He has stood for a long time without saying anything.’} \]

The two uses of go seem at first contradictory, the first indicating permanence, the second a change. Not unheard of: we have had occasion to notice a similar duality in Portuguese ficar and Scandinavian bli. As Rangkupan (1992) points out, what happens at the time of reference is the same, only what went before is different. The two senses apply to different event types. Pay1 means go on for processes and become for states. In the first case, go denotes a comparative change, in the second, an absolute one. The second denotes a change of state, the second one a state of change.

Formally, we have go\|homework in the first case, go\|<quiet in the second. The complement is a locative or means in the first case, a goal or result in the second.

---

\(^{250}\) The meaning of pay1 ‘too (much)’ compares to English too, which is but an alternative spelling of to. Excess is etymologically related to ‘go past’.
The Thai use of *maa1 'come' for a near past is easy to derive from the event type of *come by letting the event be the dependent variable on time. The *come event type becomes simply ¬now.now, which is just my characterisation of a near past. If the event is closed, we get a recent past e<now, if it is open we get an extended now e[<now.

Let us next take a closer look at *hay 'give', another central serial verb in Thai. Consider the usage of *hay 'give' in the following constructions (Rangkupan 1997):

nuan *hay ámbon jùm
Nuan *give candy Jum
‘Nuan gave candy to Jum.’

**Nuan give candy Jum**

nuan *hay jùm ?á:n nংsx ś ː kën nǐn
Nuan *give Jum read book before sleep
‘Nuan *let/made Jum read a book before going to bed.’

**Nuan give Jum read book**

nuan kamlaŋ tham ka:nbā:n *hay jùm
Nuan prog do homework *give Jum
‘Nuan is doing homework *for Jum.’

**Nuan do homework give Jum**

nuan thùp kæ:w *hay tečːk
Nuan *hit glass give break
‘Nuan hit the glass *to break it.’

**Nuan hit glass give break**

nuan bːk *hay jùm ?á:n nংsx ś ː k
Nuan *tell Jum to read a book
‘Nuan told Jum *to read one.’

**Nuan tell Jum read book**

nuan yā:k *hay jùm nāŋ loŋ
Nuan want give Jum sit down
‘Nuan wanted Jum to sit down.’

**Nuan want give Jum sit down**

In the first example, *hay is a straightforward ditransitive verb *give. In the second example *hay is an animate causative or factitive: Nuan gave Jum a book to read, i.e. made or let him read one. The third example is a benefactive, the fourth a purposive. The two remaining examples show *hay in something like a subordinating function, translating English (*for) to.

Rangkupan (1997) proposes that the semantic similarities between the various uses of *hay can be brought under a common semantic representation. My reading of this is that semantically, Thai *hay entails the same event type in all of its uses. Its syntactic variety reflects alternative abstracts of one and the same event type, i.e. *hay means the same but denotes different in its different uses.

My concrete aim here is to justify the simple event type assignments above by a devious analysis of the Thai event type *give for *hay. Thus my hypothesis too will be that Thai syntax is transparent given a suitable semantics for *hay.

How to interpret Rangkupan’s findings in my calculus? Rangkupan’s framework is that of Role and Reference Grammar, which makes her analyses germane to mine. There are differences too. Rangkupan’s frame for *give in RRG notation is

\[ \text{do}(x, \varphi) \text{ CAUSE INGR have'(y,z)}. \]

This translates to \( x \text{ do } p \text{ cause become } y \text{ have } z \) in my notation. This event type is not the same as my analysis of give. In my analysis, *give is causative of transfer of possession from subject to recipient, i.e. a possessive reading of *x cause z go from x to y. In my analysis, one cannot give what one hasn’t got. Also, this event type does not make the subject animate, for instance an attempt can give (yield) a result without meaning to. If the Thai *hay has animacy built into both subject and recipient as Rangkupan argues, *hay is better represented by replacing cause with do. This variant of my formula entails Rangkupan’s.

Next look at the factitive use of *hay in the second example. My proposal for the event type of a two-way animate factitive was the chain of events

\[ y \text{ plan } (y \text{ p cause } (y \text{ give z to x}) \text{ cause } x \text{ plan } (x \text{ q cause } x \text{ give w to y}) \text{ cause } x \text{ q}) \]
Plugging in \( q \) for \( z \) or \( w \) gets us either of

\[
y \text{ plan } (y \text{ p cause } y \text{ give } z \text{ to } x \text{ cause } x \text{ plan } (x \text{ q cause } x \text{ give } q \text{ to } y) \text{ cause } x \text{ q})
\]
\[
y \text{ plan } (y \text{ p cause } y \text{ give } q \text{ to } x \text{ cause } x \text{ plan } (x \text{ q cause } x \text{ give } w \text{ to } y) \text{ cause } x \text{ q})
\]

The first event type says \( y \) induces \( x \) to do \( q \) by giving him \( z \) in return. This is a necessitative causative reading of the factitive \textit{give}: you make someone to do something you want by giving them a deal they cannot turn down.

The second event type says \( y \) gives \( x \) the task of doing \( q \), expecting \( x \) to give something \( w \) in return. What the payback \( w \) is remains open: it can be just \( q \) itself, if \( q \) is indifferent to \( y \). This entails an abilitative reading of the factitive \textit{give}: you let someone do something they want to do.

Finnish also uses its verb for \textit{give} for a factitive: \textit{fi Anna hänen mennä ‘let/make him go’ from antaa ‘give’}. In Finnish, as in Thai, the subject and the recipient of the factitive \textit{give} are animate, or at least enough so to seem to have a mind of their own. According to Rangkupan, Thai does not allow factitives of states or achievements, while Finnish does: \textit{Anna hänen olla onnellinen / löytää kukkaroo ‘let him be happy / find the purse’}. Interestingly, only the weak abilitative reading is available for these event types, which suggests that only the giving half of the abilitative factitive event type above survives in this case:

\[
y \text{ plan } (y \text{ p cause } y \text{ give } q \text{ to } x \text{ cause } x \text{ q})
\]

Once the payback half of the causal chain is left out, the event type \( q \) no longer represents an action by \( x \), so it can be of any event type. The crucial bit is \( y \text{ give } q \text{ to } x \) which means \( y \text{ let } q \text{ go from } y \text{ to } x \), where the event type \textit{go} spells out to \( y \text{ has } q < x \text{ has } q \), i.e. control of \( q \) is transferred from \( x \) to \( y \).

In the section on benefactives, I suggested that the syntax of a beneficiary adjunct involves combinatorial transformations of

\[
x \text{ plan } (x \text{ p cause } x \text{ give } z \text{ to } y) \text{ cause } x \text{ p}
\]

Considering what this formula entails for \textit{John bake a cake for Rita}, compare my event type

\[
\text{John plan (John bake a cake cause John give z to Rita) cause John bake a cake.}
\]

to Rangkupan’s proposal

\[
[\text{want'} (\text{John,[BECOME have'} (\text{Rita, cake})])] \wedge (\text{John,[[do'} (\text{John}) \text{ CAUSE [BECOME baked’ (cake)])]} \text{ CAUSE [BECOME have'} (\text{Rita, cake})])]
\]

Given game semantics for \textit{plan}, my event type entails, like Rangkupan’s, that the subject wants the beneficiary to receive the benefit. But it entails more than Rangkupan’s formula by saying that the action is intended and that the plan is a cause of the action. It entails less than Rangkupan’s formula in that it does not entail any actual benefit – that is only in the plans.

In my representation, whether Rita gets the cake or some other benefit depends on how the free variable \( z \) is instantiated. One reading we may want here is that John does the baking in Rita’s place. Following Rangkupan’s proposal, we may then instantiate \( z \) to the event type \textit{bake a cake}: John does the baking so Rita does not have to. Who gets the cake is left open here.

In the section on benefactives, I suggested that the syntax of a beneficiary adjunct involves combinatorial transformations of

\[
y \text{ plan } (p \text{ cause } y \text{ give } z \text{ to } x) \text{ cause } p
\]

Thai uses here a serial verb construction which leaves the verb \textit{give} on the surface.

\[
p \text{ (because } y \text{ plan } p \text{ cause } y \text{ give } (z \text{ to } x)
\]

Next look at the purposive use of \textit{hây} in the fourth example. It appears that the construction allows an explicit subject in the purpose clause:

\[
\text{nuan thúp kæ:w hây kæ:w tæ:k}
\]

\text{Nuan hit glass give glass break}

‘Nuan hit the glass \textit{in order for} the glass \textit{to break’}.

\[
\text{Nuan hit glass give glass break}
\]

The event type of a final (purposive) connective in my construal was

\[
(x \text{ plan } p \text{ cause } q) \text{ cause } p
\]

The Thai construal of this event type seems modeled after the benefactive event type as
Nuan plan (Nuan hit glass give break to glass) cause Nuan hit glass

or, in more surface true order,

Nuan hit glass because Nuan plan Nuan hit glass give break to glass

What Thai does on the surface is suppress the plan and some redundancy. Note that in this transform, break is inside the scope of plan, so the event type does not entail the glass breaks. No wonder a finite purposive clause in phwa takes subjunctive mood in Thai.

Rangkupan points out differences in usage between benefactive hây and English for. In particular, hây requires animate participants and disallows simple event type (state or achievement). Thus The sun shines for all of us or I found something for you don’t translate into hây. The differences suggest that Thai hây is more narrowly benefactive than the English for.

There remains the use of hây in the complement of a preferential event type to consider.

jǔm yà:k pay na:ŋliáŋ kàp phon
‗Jum wants to go to the party with Phon.‘

nuan yà:k hây jǔm nâŋ loŋ
‗Nuan wanted (for) Jum to sit down.‘

phon bê:k nuan hây jǔm nâŋ loŋ
‗Phon told Nuan Jum should sit down.‘

Rangkupan points out that Thai yàk only allows propositional complements, no person object like English I want you.

Hây appears when the subject of the complement event type is different from the subject of the matrix. This makes hây resemble in function the English for complementiser. It cannot be a coincidence that hây and for both mark purpose and beneficiary.

Again, a bit of semantic archaeology helps to get a handle on this use of hây. Compare

Nuan planned for Jum to eat rice.

y plan y give z to x cause x eat rice

Nuan planted rice for Jum to eat.

y plan y plant rice cause y give rice to x cause x eat rice

The first sentence is a preferential complement construction. The second one is a transitive clause with a beneficiary and a purpose. On the surface, only the order of the complements is different. I submit that the latter construction is the source of the former. The beneficiary is fronted to become the object of the higher clause and the subject of the lower. The voice of eat changes from passive to active to reflect the change of subject. (Finnish infinitivals in the latter construction are morphologically passive.)

So what is the answer to Rangkupan’s question about the part of speech of hây in its various uses? If one is wants to write a simple surface true categorial grammar for Thai, then hây will indeed get different categories ascribed to it, always depending on what categories we ascribe to the rest of the sentence. On the other hand, one can also hang on to the hypothesis that hây means ‘give’ in all of its uses, if one is prepared to construct a lot of invisible structure around it. For instance, take Thai ‘Nuan do homework give Jum’. On the surface, hây is a preposition here. In event structure, it entails the event type give. English and Thai share the same event types. The surface difference is that English lexicalises the goal of give, Thai the event type.

Lao (Kelly/Melinger 2001:83) is closely related to Thai:

kuu3 haj5 man I give he ‘I gave it to him’
kuu3 haj5 ngen2 man2 I give money he ‘I gave money to him.’
kuu3 qaw3/song1 ngen2 haj5 man2 I take/send money give he ‘I took/sent money to him’

From the combinatorial point of view, the transformation from x take y . x give y to z to x take y give z can be construed as an instance of the distributive combinator S:

take (x y) give (x y) z = S(take give (x y) z
Hungarian

Hungarian expresses aspect in transitive verbs through a definite/indefinite object marking on the verb and through resultative morphemes (meg, le, ki). Kiefer (1982:318) claims prefixing expresses a (grammatical) perfective/imperfective aspect distinction, while Csató (1994) argues that they express a lexical actionality (Aktionsart) distinction between ‘transformative’ (achievement-accomplishment, i.e. closed) and ‘nontransformative’ (activity-state, i.e. open) verbs. I have claimed perfective/imperfective aspect expresses the very same semantic distinctions as closed/open Aktionsart. What Csató is pointing at are the following differences. (i) Hungarian allows prefixed verbs as complements of begin. (ii) Hungarian prefixed verbs are not always future in the present. They have progressive meaning when the particle follows the verb as an independent word. (iii) Hungarian prefixed verbs can occur with the future auxiliary fog. Russian uses perfective present for future.

```
Kezdem megírni a levelet. ‘I am starting to write up the letter.’
Megyek le a boltba. ‘I am on my way down to the shop.’
Most nem írja a levelet meg és nem is fogja megírni. He is not writing the letter up now nor will he write it up (later).
```

Like Russian, Hungarian has only one past tense which does duty for both simple past and perfect. It interacts with prefixing in some of the same ways as Russian:

```
Olvastad ezt a könyvet? ‘Have you read this book (at all)?’
Kolvstad ezt a könyvet? ‘Have you finished (did you finish) this book?’
```

In the existential perfect use the result morpheme, if any, appears after the verb. An adverb már already may come in between:

```
Réka ment (már) ki a kertbe. Reka go past already out the garden to ‘Reka has been to the garden (before).’
Réka ki ment a kertbe. Reka out go past the garden to ‘Reka went out to the garden’
```

The existential perfect reading is excluded for unique events:

```
Réka szú letett (már) Budapesten. Reka born be past already Budapest in ‘Reka has been born in Budapest (before).’
```

Inuktitut

Inuktitut (Inuit, Eskimo) (Nowak 1994) is a polysynthetic language. Comparing to more familiar languages, less whitespace is used between morphemes. According to Nowak, Inuktitut has no obligatory tense inflection on the verb, but has a good number of optional temporal and aspectual affixes. The unmarked form of a verb in Inuktitut is nonfuture. Here are some Inuktitut affixes: 251

<table>
<thead>
<tr>
<th>Affix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>aullaq-puq</td>
<td>leave-he</td>
</tr>
<tr>
<td>aullaq-liq-puq</td>
<td>leave-prog-he</td>
</tr>
<tr>
<td>taku-rataaq-para</td>
<td>see-just-i/it</td>
</tr>
<tr>
<td>tikit-qauvugut</td>
<td>arrive-a short while ago-we</td>
</tr>
<tr>
<td>taku-juu-jara</td>
<td>see-a long while ago-i/it</td>
</tr>
<tr>
<td>aullaq-lauq-tuq</td>
<td>leave-past-he</td>
</tr>
<tr>
<td>sinik-niaq-tut</td>
<td>sleep-soon-they</td>
</tr>
<tr>
<td>niri-lang-a-junga</td>
<td>eat-about to-I</td>
</tr>
<tr>
<td>titiraq-laq-pagit</td>
<td>write-will-I/you</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘he leaves’</td>
</tr>
<tr>
<td></td>
<td>‘he is leaving’</td>
</tr>
<tr>
<td></td>
<td>‘I just saw it’</td>
</tr>
<tr>
<td></td>
<td>‘We arrived a short while ago’</td>
</tr>
<tr>
<td></td>
<td>‘I saw it a long time ago’</td>
</tr>
<tr>
<td></td>
<td>‘he left’</td>
</tr>
<tr>
<td></td>
<td>‘they are going to fall asleep’</td>
</tr>
<tr>
<td></td>
<td>‘I’m about to eat’</td>
</tr>
<tr>
<td></td>
<td>‘I will write to you’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>leave\now</td>
</tr>
<tr>
<td></td>
<td>prog leave\now</td>
</tr>
<tr>
<td></td>
<td>see\now</td>
</tr>
<tr>
<td></td>
<td>arrive.short.now</td>
</tr>
<tr>
<td></td>
<td>see.long.now</td>
</tr>
<tr>
<td></td>
<td>leave\then\now</td>
</tr>
<tr>
<td></td>
<td>now.soon.sleep</td>
</tr>
<tr>
<td></td>
<td>now.eat</td>
</tr>
<tr>
<td></td>
<td>now&lt;write</td>
</tr>
</tbody>
</table>

Table 67

Nowak stresses a distinction between definite (witnessed) and indefinite (nonwitnessed) tenses in Inuktitut. In particular, the participle (m/v)iniq reports knowledge by description, the simple past lauq knowledge by acquaintance. My guess is that sima is a result perfect (it is glossed must have and apparently in Bybee 1994:97) lauq is a perfective, and miniq is a perfective perfect. An interesting feature is the composition of lauq and sima both ways.

---

251My glosses are aimed at readability rather than morphological accuracy. See Nowak (1994) for scholarly details.
Irish

Irish, like English and to some degree Portuguese, makes a major split between simple (generic) and progressive aspect. Irish has extended the progressive form to all imperfective uses except generics, which explains the overapplication of the progressive in Irish English (Curme 1931:387): *I was never knowing such a girl, so honest and beautiful, Try again, Martin, try again, and you’ll be finding her yet,* contrasting with the generic *I do be at my lessons every evening from 8 to 9 o’clock.* The progressive is a periphrastic form from the copula and a locative gerund (‘a-writing’). The copula too has a progressive-habitual opposition: *ta/bíonn Seán anseo ‘John is (usually) here’.* The combination of the habitual copula with the progressive composes into a habitual progressive *gen prog e* (*bíonn Seán ag ól ‘John is (in the habit of) drinking’*), a sign of a progressive well advanced toward imperfective. The Irish tense and aspect system maps neatly to formal primitives:

<table>
<thead>
<tr>
<th></th>
<th>&lt;now&gt;</th>
<th>⊙now</th>
<th>now&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>gen</td>
<td>d’ól</td>
<td>d’oladh</td>
<td>ólann</td>
</tr>
<tr>
<td>prog</td>
<td>bhí ag ól</td>
<td>tá ag ól</td>
<td>beidh ag ól</td>
</tr>
<tr>
<td>gen</td>
<td>bhíodh ag ól</td>
<td>bionn ag ól</td>
<td></td>
</tr>
</tbody>
</table>

**Table 69**

Harris (1984) counts in Irish English four different forms corresponding to different senses of the English perfect: simple past for indefinite perfect in *I never saw a gun in my life nor never saw a gun fired,* an Irish type perfect for hot news in *A young man’s only after getting shot out there,* a possessive perfect for resultative perfect in *She’s nearly her course finished,* and present tense for extended now in *I know his family all my life.*
Standard English | Irish English | Irish | Meaning | Notation
--- | --- | --- | --- | ---
have never Ved | never Ved | preterit | neg existential | ¬(b<now)
has just Ved | is after Ving | Cop S tréis (O) V | hot news | b.now
has Ved | has it Ved | Cop S PastPrt Loc | result perfect | b\r\fnow
has Ved | Vs | present | extended now | a\f<now

Table 70

Kikuyu

The following table of Kikuyu tense and aspect forms is based on Johnson (1981). There are three aspects which seem to map straightforwardly to perfective, imperfective, and perfect. These aspect distinctions are upheld in nonfuture tenses only. Kikuyu has a metric tense system with distinction between immediate (hodiernal, ‗today‘), near (hesternal, ‗yesterday‘), and remote tenses. These names are justified by the fact that the three tenses co-occur with rucini ‘today‘, ira ‘yesterday‘, and eyo ‘day before yesterday‘, respectively. Johnson (1981) has no data on the full range of the tenses in Kikuyu but quotes a description on the closely related language Luyia (Appleby 1961):

There is no general past tense; any one of the past tenses indicates roughly how long past you are referring to. This indication is sometimes relative rather than absolute; e.g. the Near Past tense indicates the near past period of time, usually within the preceding 24 hours or so; but in speaking of years, it would be used of last year; in speaking of generations, it would be used of the last generation, of wars, of the last war; and so on. (p. 40)

This suggests that the diurnal metric is the default for a three-way deictic tense system. I have tweaked Johnson’s glosses for the forms for better fit with my hypotheses. The first a/e is third person pronoun. The glosses of the simple aspect tenses are not diurnal, but the meanings are compatible with a remote/near past/present tense contrast. The deictic properties of the various forms need more attention, as well as aktionsarts and discourse usage.

<table>
<thead>
<tr>
<th>Tense/aspect</th>
<th>φ</th>
<th>ire pf</th>
<th>aga pf</th>
<th>ite perf</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ</td>
<td>a-hanyuk-ire</td>
<td>a-hanyuk-aga</td>
<td>a-hanyuk-ite</td>
<td></td>
</tr>
<tr>
<td>a &lt;&lt;now</td>
<td>a-a-hanyuka</td>
<td>a-a-hanyuk-ire</td>
<td>a-a-hanyuk-aga</td>
<td>a-a-hanyuk-ite</td>
</tr>
<tr>
<td>remote past (earlier)</td>
<td>‘He has run’</td>
<td>‘He ran (before yesterday)’</td>
<td>‘He was running (before yesterday)’</td>
<td>‘He had run (before yesterday)’</td>
</tr>
<tr>
<td>ra &lt;&lt;now</td>
<td>a-ra-hanyuka</td>
<td>a-ra-hanyuk-ire</td>
<td>a-ra-hanyuk-aga</td>
<td>a-ra-hanyuk-ite</td>
</tr>
<tr>
<td>near past (yesterday)</td>
<td>‘He is already running (now)‘</td>
<td>‘He ran (yesterday)’</td>
<td>‘He was running (yesterday)’</td>
<td>‘He had run (yesterday)’</td>
</tr>
<tr>
<td>ku &lt;&lt;now</td>
<td>e-ku-hanyuka</td>
<td>e-ku-hanyuk-aga</td>
<td>e-ku-hanyuk-ite</td>
<td></td>
</tr>
<tr>
<td>present (today)</td>
<td>‘He will run (today)’</td>
<td>‘He has been running (earlier today)’</td>
<td>‘He has run (today)’</td>
<td></td>
</tr>
<tr>
<td>ri now &lt;&lt;</td>
<td>a-ri-hanyuka</td>
<td></td>
<td></td>
<td>‘He will run (soon)’</td>
</tr>
<tr>
<td>near future (soon)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ka now &lt;&lt;</td>
<td>a-ka-hanyuka</td>
<td></td>
<td></td>
<td>‘He will run (tomorrow or later)’</td>
</tr>
<tr>
<td>remote future (later)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 71

Givón (1972,1982) discusses a metric system from Bemba, a Bantu language with perfective suffix -ile and perfect prefix à. In Bemba too default metric implicatures seem to be transposable in practice:

**Context:** Is Joe still working?

---

252Johnson’s original glosses are a-ra-hanyuka ‘he is running right now but he hasn’t been running for long’, e-ku-hanyuk-aga ‘He had been running earlier today’, e-ku-hanyuka ‘He will run (today, within a few hours)’.
Response: a-à-boomba. ‘He’s already worked the day before yesterday.’
… n-à-ti-ile n-ci-isa, John elyo na-o a-à-ya…
… I came (long ago), and by then John had already left (long before)…
… when I came, he had already left …

Lezgian
Lezgian (Haspelmath 1994, Johanson 1998) is a Caucasian language spoken in Daghestan and Azerbaijan. It has a rather transparent tense and aspect system:

<table>
<thead>
<tr>
<th>Tense Type</th>
<th>Suffix</th>
<th>Meaning</th>
<th>Affix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperfective</td>
<td>fi-z-wa</td>
<td>‘is going, goes’</td>
<td>ipf</td>
</tr>
<tr>
<td>Continuative imperfective</td>
<td>fi-z-ma</td>
<td>‘is still going’</td>
<td>still ipf</td>
</tr>
<tr>
<td>Future</td>
<td>fi-da</td>
<td>‘will go/goes’</td>
<td>fut</td>
</tr>
<tr>
<td>Past Future</td>
<td>fi-da-j</td>
<td>‘would go, went’</td>
<td>pret fut</td>
</tr>
<tr>
<td>Past Imperfective</td>
<td>fi-z-wa-j</td>
<td>‘was going, went’</td>
<td>pret prog</td>
</tr>
<tr>
<td>Past Continuous Imperfective</td>
<td>fi-z-ma-j</td>
<td>‘was still going’</td>
<td>pret still ipf</td>
</tr>
<tr>
<td>Past Imperfective Future</td>
<td>fi-z-da-j</td>
<td>‘would be going, go’</td>
<td>pret prog fut</td>
</tr>
<tr>
<td>Aorist</td>
<td>fe-na</td>
<td>‘went’</td>
<td>pf</td>
</tr>
<tr>
<td>Perfect</td>
<td>fe-n-wa</td>
<td>‘is gone’</td>
<td>perf pf</td>
</tr>
<tr>
<td>Continuative Perfect</td>
<td>fe-n-ma</td>
<td>‘is still gone’</td>
<td>still perf pf</td>
</tr>
<tr>
<td>Past Aorist</td>
<td>fe-na-j</td>
<td>‘went earlier’</td>
<td>pret pf</td>
</tr>
<tr>
<td>Past Perfect</td>
<td>fe-n-wa-j</td>
<td>‘had gone’</td>
<td>pret perf pf</td>
</tr>
<tr>
<td>Past Continuous Perfect</td>
<td>fe-n-ma-j</td>
<td>‘was still gone’</td>
<td>pret still perf</td>
</tr>
</tbody>
</table>

Table 72
The imperfective covers states, progressives, and habits. The future da covers the rest of the nonpast domain, i.e. future and generic event types. It has present reference in a small number of dispositional states (want, know). Haspelmath (1994) analyses it as the remnant of an older extended present tense which is being ousted by the current imperfective, a periphrastic progressive formed out of the infinitive and wa ‘be’. The past future is used like English would in the consequent of counterfactual conditionals and for past habits. The Aorist is a perfective past used in narratives. The Past Aorist refers to situations in the remote past, situations before the main story line, situations that do not obtain anymore, and situations whose effect has been canceled. The perfect na is a regular result perfect. The Past Perfect is the past of the perfect.

The continuative ma still is exotic only in being is suffixal and integrated to the tense system. The semantics seems straightforward. The continuative perfect is a resultative perfect (as noted earlier, anterior perfect is not compatible with still).

Turkish
Turkish makes an obligatory choice between two past tense suffixes: direct experience -di and indirect experience mis: gel-di ‘it came’ vs. gel-mis ‘it seems to have come’. The evidential mis is used for inference, hearsay and surprise (cf. section on evidentiality). It is also used for myths, folktales, dreams, and jokes. Etymologically, it is a(n active)
perfect(ive) participle. With open event types, it becomes a quotative particle with no past entailments, expressing hearsay or surprise:

Selma bura-da-y-mis ‘Apparently, Selma is here’.
Araba-si yok-mus. ‘It is said he doesn’t have a car.’

Mis can be doubled, the first occurrence a perfect and the second a quotative particle. It can be put in the past tense (di>ti) to form a regular pluperfect:

Kemal gel-mis-mis. ‘Kemal is said to have come.’
Kemal gel-mis-ti. ‘Kemal had come.’

Again, I would suspect di for a definite (perfective) past and mis for a perfect become evidential.

**Arabic**

Cohen (1989) presents classical arabic as a pure two-way imperfective-perfective aspect system without morphological tenses. An example paradigm for root *ktb* 'write' is (Cohen 1989:41)

<table>
<thead>
<tr>
<th>Perfective</th>
<th>(either)</th>
<th>Imperfective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicative</strong></td>
<td><em>kataba</em></td>
<td><em>yaktubu</em></td>
</tr>
<tr>
<td><strong>Active participle</strong></td>
<td><em>kâtib</em></td>
<td></td>
</tr>
<tr>
<td><strong>Passive participle</strong></td>
<td><em>maktûb</em></td>
<td></td>
</tr>
<tr>
<td><strong>Subjunctive</strong></td>
<td><em>yaktuba</em></td>
<td></td>
</tr>
<tr>
<td><strong>Optative-jussive</strong></td>
<td><em>yaktub</em></td>
<td></td>
</tr>
</tbody>
</table>

**Table 73**

The temporal interpretation of a form depends on accompanying adverbials and the type of discourse it is in. Using the récit/discours distinction of Benveniste between past narrative and present tense discourse, we have the following table (Cohen 1989:85):

<table>
<thead>
<tr>
<th>Imperfective</th>
<th>Perfective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Récit</strong></td>
<td>Past imperfective</td>
</tr>
<tr>
<td><strong>Discours</strong></td>
<td>Nonpast</td>
</tr>
</tbody>
</table>

**Table 74**

Particles optionally disambiguate the tense of the two aspect forms (ibid. 185):

<table>
<thead>
<tr>
<th>Imperfective</th>
<th>Perfective</th>
</tr>
</thead>
</table>
Past  
(kāna) ‘was’  
(kāna) (qad) ‘was already’ (pluperfect)

Present  
-  
(qad) ‘by now’ (present perfect)

Future  
(sa(wfa)  
(yakûnu) (qad) ‘is by then’ (future perfect)

Table 75

Tense, Mood, Aspect, Diathesis
Their Logic and Typology
Lauri Carlson
University of Helsinki
Department of General Linguistics

Part III. Typology
The cross-linguistic survey of Part II tends to minimise differences between TMA forms across languages. Many different forms in different languages end up with the same formalisation. This does not yet warrant one to one translation within a category (Andersson 1972,1978, Skov-Larsen 1984, Santos 1996). Forms which instantiate the same cross-linguistic category are not equivalent, although they have a significant range of common contexts. The problem could be alleviated by splitting categories to obtain an even finer grid. I will not try to do so. This is because I believe the reasons for failure of translatability are often located elsewhere. Here is a list of possible causes for mismatch.

- The formalisation of some forms is wrong (too wide or narrow).
- The forms belong to different paradigms. The range of a form is constrained by what else is available in the language.
- There are differences in the context. Lexical entries or adverbials may be different.
- Competing factors. TMA is just one part of the message, and closest TMA translation may be compromised to convey something else more efficiently.
- Usage differs so that preferred wording is conventionally different (Santos 1996).

Hedin (1998) raises the same issue. For example, consider irresultative event types and their exponents in four languages:

<table>
<thead>
<tr>
<th>English</th>
<th>Russian</th>
<th>Bulgarian</th>
<th>Greek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you seen this film?</td>
<td>pres perf</td>
<td>pret ipf</td>
<td>pres perf ipf</td>
</tr>
<tr>
<td>¬see.see. ¬see&lt;now</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Who has been opening the window?</td>
<td>pres prog</td>
<td>pret ipf</td>
<td>pres perf ipf</td>
</tr>
<tr>
<td>¬open.open ¬open&lt;now</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As a child, I once fell from that tree</td>
<td>pret</td>
<td>pret ipf</td>
<td>pret pf ipf</td>
</tr>
<tr>
<td>¬fall.fall ¬fall&lt;now</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 76
It is easy to show that the form used in each language is consistent with the event type. The trick is to predict that just these forms are the preferred ones in each. For instance, the English progressive is possible in the second example but not the first, obviously because the process implicature of the English progressive is out of place with see. A contrast between present and past focus is realised in those languages which can make the distinction (present perfect vs. simple past). A cycle is closed – hence the aorist in Bulgarian and Greek – but not half-closed – hence the imperfective in
Bulgarian and Russian. The appearance of pluperfect as a past resultative in Greek makes sense after the fact (cf. English *Who had opened the window?*), but can it be predicted from the Greek paradigm?

A likely case of lexical difference is the differential behavior of ancient Greek *peitho* 'prevail upon' and its modern successor *pihdo* 'persuade' (Hedin 1998). As the difference of gloss indicates, *peitho* was an acquisition, denoting both the act of persuading and the result of having persuaded (Liddell/Scott 1968 *s.v. peitho*).

The aim of this chapter is not to replace, or even correct, earlier work on TMA typology (Dahl 1985, 1998, Bybee 1994, Thieroff 1994), but to explicate it with the calculus of events.

**Structuralist typology**

There are a number of essentially structuralist notions, including schematic vs. prototypical meaning, paradigm pressure, contextual (conversational) vs. conventional meaning (Smith 1991:24) that help maintain the thesis of simple universal invariant meaning while allowing at the same time that languages behave differently (Bache 1995 is recent attempt in this genre). This chapter takes up such issues and looks for ways to capture them in the calculus.

**Paradigm**

The main structuralist tenet is that in language, *tout se tient*: forms do not exist independently, but form systems of options which divide up a semantic field between themselves. What a form means is not (only) constrained by its inherent denotation, but its position in a system. This is only a guiding principle, contested by the opposing forces of nature and history (natural kinds do not form a tight system, and historical accidents cause disturbances in the system), but it is a real one.

The related structuralist notion is that of a *paradigm*: a language only has so many tense and aspect forms, and if something has to be expressed, one of the alternative forms must be used. If it is not this one, then it must be that. What one tense means depends on what the others (don’t) mean.

Paradigmatic contrast provides an alternative a way to define tenses, not constructively by simpler formulas of the calculus but by subtraction, in terms of the other tenses they complement. The effective meaning of a form whose schematic meaning overlaps but contrasts with the meaning of a marked form is the difference of the unmarked form and the marked one. Writers who capitalise on this line of thought, championed by Jakobson (1932), include Forsyth (1970), Johanson (1971, 1998) and Bache (1985). Logically, a paradigm forms a Boolean universe to take complements against.

For instance, Bybee et al (1994:83) suggest that the main difference between a language with a simple past and one with a past perfective is the presence or absence of a past imperfective.253 Johanson (1998:§8.10) concludes that a contrastive imperfective is needed for a perfect to develop into a perfect. Another case where contrasts play a role is the division of the past by metric tenses (Bybee 1994:100).

This sort of subtraction explains the observation (dubbed layering hypothesis in Bybee et al. 1994:231) that as new marked forms appear to a paradigm, they tend to narrow down the application of the earlier ones, with the result that the range of application of an unmarked form may end up as an essentially disjunctive set of senses. In the present calculus, this situation can be literally represented by defining the meaning of an unmarked form as a Boolean difference of a unitary general meaning and a number of marked meanings.

Layering is part of the process of grammaticalisation. takes place in all domains covered in this work. Examples: tense and aspect (progressive, perfect), mood (subjunctive, future), diathesis (reflexive, passive).

**Aspect paradigm**

In the section on aspect shift, it was observed that unmarked aspect shift is blocked by a marked aspect contrast. Hence, the fewer marked aspects there are, the more room there is for unmarked aspect shift. Symbolising by $e^*$ the closure of $e$ under unmarked aspect shifts (the language defined by null transitions in the aspect transition network), a language with no aspects, the only form of a verb would denote $e^*$.

By the same token, an unmarked imperfective $ipf \ e$ covers $e$, while a marked imperfective $ipf! \ e$ is $ipf \ e^*$ which leaves over progressive and iterative event types. A marked perfective $pf! \ e$ covers $pf \ e^*$ so $pf! \ e$ equals $\sim e^* \sim e$ for closed as well as open event types $e$.

Russian imperfective is unmarked on process accomplishments, e.g. *chitat* ‘read’, *prosit* ‘ask’, *zavtrakat* ‘have breakfast’, but marked on achievements *naidat/naxodit* ‘find (repeatedly)’, *umeret/umdurat* ‘die (plurally)’ (Chaput 1990). Conversely, perfective is marked on the former group, unmarked on the latter. For instance, imperfective *prosit* ‘asked, was asking, used to ask’ is unmarked while *poprosit* ‘asked once, successfully’ is markedly definite, specific...

253 Overall, Bybee et al (1994:22,138) want to emphasize the contribution of substantive or focal meaning to grammatical development as compared to contrastive meaning. Obviously both factors contribute.
and resultative, and conversely, perfective nashel ‘found’ is unmarked but imperfective naxodil ‘used to find’ specifically iterative.

Unmarked iteration e\^ covers e, marked iteration e\^e alias ee^ does not. English does not mark iteration, so knock is vague between semelfactive and frequentative readings. Finnish kopauttaa ‘knock’ is also vague about iteration, but its marked derivatives are not: momentaneous kopauttaa is only semelfactive, frequentative koputiella only iterative.

An unmarked progressive covers the special case where the part picked out by prog e is the whole of e; while a marked progressive which contrasts with a simple form is likely to exclude it. A marked progressive prog! e can then be defined as the Boolean difference prog ele. Conversely, an unmarked simple aspect is left vague about those aspect shifts which are not explicitly restricted by competing forms in the aspect paradigm of the language. For instance, the range of English simple aspect could be described as e\^prog! e. This negative definition explains the piecewise, disjunctive character of the English simple aspect: for states, which have no marked progressive, simple aspect is open; for activities, which have a separate progressive, simple aspect is usually closed. The simple form does not block aspect shifts, the progressive does. Simple states have closed inceptive readings, simple events have open generic ones.

Finnish has no grammatical progressive (except for case marking on resultative transitive verbs), so activity verbs are vague between simple and progressive aspect; for instance Hän söi päivällistä translates ‘He had dinner’, or ‘He was having dinner’. In Russian activity verbs, the imperfective is also unmarked, so past imperfective obedal translates ‘He was having dinner’, ‘He used to have dinner’, ‘He has had dinner’, or ‘He has been having dinner’. In English and Portuguese, which have a marked progressive, it only covers proper progressive prog! e (proper part or proper iteration), thus He was having dinner or jantava can only mean ‘he was in the middle of the dinner’ or ‘he was in the habit of dining’, not ‘he had a meal’.

**Tense paradigm**

The structuralist notion of tense paradigm can also be approximated in the event calculus through Boolean complementation. The relative difference of two event types is also an event type. A general event type can be divided into a number of narrower disjoint event types. This allows making literal sense of the structuralist idea that different languages divide up semantic space differently.

A minimal tense system has just one tense, an extended present <=< now <= covering the entire time line. A simple past tense e now narrows down the simple present to the difference <=< now <= e now, which leaves over a nonpast tense now <=. Further subtraction of a future tense now e leaves just simple present e now. We already saw that the simple past e now is the join of a remote and a near past e now \( \cup e now\). Subtracting a near past (perfect) from a simple past, e now \( \cap e now\), we are left with a marked remote past e now.\(^{255}\)

Along the same lines, extended present e now can be shown to include present progressive prog e now. Subtracting the progressive, we are left with a nonprogressive simple present e now restricted to states, habits, and dispositions. Subtracting present progressive prog e now from nonpast now <= e leaves nonprogressive present and future event types:\(^{256}\)

\[
\text{now} <= \text{\{e} \cup \text{prog e now} = \text{e now} \cup \text{e} <= \text{now}
\]

This type of paradigmatic analysis has an analogue in the logical notion of completeness of a system of tenses. A study of the logical relations between the tenses and aspects in a language should show that the tense and aspect system of a given language is complete (all semantically possible tenses can be expressed syntactically, Kamp 1968).

**Markedness**

Markedness is another structuralist notion (Jakobson 1932, 1957, Comrie 1976:§6, Smith 1991:§1.3.1, Bache 1995). Morphological markedness means just what it says: the marked member of an opposition is the one which carries some grammatical marking. Semantically, marked readings are more specific or complex than unmarked ones, or they require contextual support or coercion. The most straightforward connection obtains between the two types of markedness is when morphologically marked forms are also semantically marked. However, morphological and semantic changes are apt to skew this association. A morphologically marked form may spread to become the default, restricting an older and simpler form to semantically peripheral contexts (Chung/Timberlake 1985, Bybee et al. 1994).

There is a connection to the notion of paradigm here: the unmarked member of an opposition can cover both sides of a distinction, except when narrowed down by a contrast with the marked member; while the marked member only covers

\(^{254}\)The main observation in the proof is that <=< now equals e now \( \cap e now \cap now \cap e\).

\(^{255}\)This seems to describe the situation in French, where passé simple has become a remote simple past in contrast to passé composé.

\(^{256}\)Haseplmath (1994:276) suggests this is what happened in Lezgian, a language spoken in Daghestan in the eastern Caucasus.
one side of the distinction. Thus logically, a markedness opposition is a *privative* opposition between the unmarked case, the general rule or default, and the marked cases, the exceptions.

Cases of markedness in tense and aspect are the following.

The markedness of lexical event types is related to their definitional complexity. This makes states the simplest event type, followed by simple changes and their denials. Löbner (1990:105) argues that in any square of opposites, the positive weak operator (*some*) is least marked, its dual (*every*) and denial (*none*) come next, and the denial of the dual (*not every*) is most marked. The square of changes (*start, stop, stay, stay not*) does not quite fit this prediction, for the denial of dual *stop* seems less marked than the denial of the weak operator *stay not* (*not start*).

Perfective is the unmarked grammatical aspect of closed event types, imperfective that of open ones. The only aspect of Russian unpaired aspect verbs matches lexical event type (Bache 1985:50). The use of an unmarked combination (imparfait for open event types) does not call for explanation, nor does perfective for closed ones. Explaining is needed when a marked combination is used, and when the unmarked one is not.

The unmarked combinations of aspect and tense are imperfective present and perfective past/future. If aspect is not marked, the present tense is the unmarked tense and the past and future are marked (English). Many languages only have a perfective/imperfective distinction in the past tense (Portuguese).

Perfective present is marked: it implies a forced fit between open speech time and closed event. Imperfective past is marked: it implies a shift of perspective to a remote reference point. Progressive and habitual aspect get morphologically marked in the past tense.

If a language has both past/nonpast and perfective/imperfective distinctions (and no future), then the nonpast perfective marks future (Finnish, Russian, Georgian). In languages with a future/nonfuture tense distinction; the perfective/imperfective contrast marks past/present (Hopi). In a pure aspect language, a perfective serves as a past form (Chinese).

Future is marked: In terms of McTaggart’s (1927) distinction between A and B series of time, the first split is not the A series trichotomy (past-present-future), but a B series dichotomy (before/not before now or after/not after now) *After* is the marked member in this series. Future is modal (the branching future model).

An unmarked passive perfect is resultative, an active perfect is experiential. Progressive is marked on states and achievements. Metric tenses are marked compared to topological ones.

Negated perfective aspect is marked and entirely absent from some languages (Finnish). In languages which allow the combination (French, Russian), a negated perfective highlights a gap between trial and result: *Achille n’attrapa pas la tortue* ‘Achilles did not catch up with the tortoise’. Raible (1990) observes that marked combinations of tense and aspect are often replaced by suppletion. For instance, the paradigms of *be, become, stop, remain, come, go, visit* are mixed in many languages.

Lorsque j’appris que ma voisine avait une compagne, je *fus* la voir. ‘When I learned that my neighbor had a friend, I went (was) to see her.’

Não estava em casa quando *lá* foram esta manhã. ‘I wasn’t at home when you came/were there this morning.’

The TMA form of states is unmarked. The same applies to stage directions, performatics, generics and other timeless reports. In Russian, imperfective is usual. The same holds for Bulgarian (Lindstedt 1985:140). A possible cross-linguistic generalisation is that performatics (like imperatives) exhibit unmarked TMA forms (Dahl 1984a).

Frawley (1992) following Chung and Timberlake (1985) classifies languages as open or closed languages by the grammatically marked aspect in the language. By this criterion, Russian is predominantly a closed language (perfective is marked, imperfective unmarked), while English is an open or dynamic language (progressive is marked).

This is all part of the lore. A novelty is if such markedness observations can be deduced from the calculus. It is possible to show that the following equations hold. The examples give a sample of what is involved.

\[
\begin{align*}
\text{b} &= \text{pf b} & \text{die equals die once} \\
\text{a} &= \text{ipf a} & \text{be alive equals live} \\
\text{p} &= \text{prog p} & \text{walk equals be walking} \\
\text{a} &= \text{a}^* & \text{walk equals keep walking} \\
\text{d} &= \text{gen d} & \text{worked equals be used to work}
\end{align*}
\]

Table 77

In other words, aspects are identity operators on their native event types, just as topological closure is an identity on closed events and interior on open ones.
The above identities do not imply that native aspect is without effect. Although the identity holds for entire event types, the automorphism need not be an identity on event tokens. Native aspects have clear effects on implicatures. For one thing, there are granularity implicatures depending on whether the aspect maps events to their subevents or superevents. Second, an explicit aspect blocks alternative unmarked aspect shifts.

The logic of marking is this: a mark is unmarked when it carries information. Conversely, marking on a degenerate (improper, limiting, default) case is marked. For instance, whole is a marked case of part or one is a marked case of many. The marked or proper relation subtracts the degenerate case. Here is a partial list of such inequalities and their unmarked counterparts:

\[
\begin{array}{lllll}
\text{improper} & \text{degenerate} & \text{equals} & \text{proper} & \text{reading} \\
\emptyset \subseteq * & * \setminus \emptyset & + & *! & \text{at least once} \\
e \subseteq e+ & e+ \setminus e & ee+ & e+! & \text{at least twice} \\
e \leq e & \leq \setminus e & e \leq f & e \leq! f & \text{proper past} \\
\emptyset \lhd < & < \setminus \emptyset & < & <! & \text{remote past} \\
e \lhd e & \lhd \setminus e & e \lhd f & e \lhd! f & \text{proper preference} \\
e \in e & \in e \setminus e & in! e & \text{properly in} \\
e \gen e & \gen e \setminus e & \gen! e & \text{generic nonactual} \\
b \subseteq pf b & pf b \setminus b & pf! b & \text{happen once} \\
e \subseteq pl e & pl e \setminus e & pl! e & \text{at least two} \\
\end{array}
\]

Table 78

The left column includes improper versions of each listed event type. The result of subtracting the marked degenerate case gives the unmarked event type on the right.

The properness operator ! which subtracts the degenerate case is an inverse of the optionality operator ? which adds it. For instance,

\[
\begin{align*}
e! & = e! \setminus e \\
e * & = e+ \setminus e \\
e+ & = e^*!!
\end{align*}
\]

In the next section, we consider the case that the subtraction operator is priority operator.

\section*{Categorisation}

My point in this section is that classical Aristotelian categorisation and prototype semantics are not incompatible, but, once again, dually related.

The classical criterial definition of Plato and Aristotle is intensional in that it narrows down extension by increasing intension, like defining a sparrow by taking meets:

\[
\text{animal} \cap \text{bird} \cap \text{fly} \cap \text{small} \cap \text{brown} \cap \text{biped} \cap \text{beak} \cap \text{feather}
\]

Its dual is a collective extensional definition by enumeration, like defining a bird as sparrow or crow or swan or ... The classic writings on definitions spend time chasing out the natural tendency to frame definitions in both ways. In a taxonomy concepts form a tree of Boolean sums of genera, species and differentiae where summum genus is the root, infimae species are leaves, the species label the nodes and the differentiae label the arcs. The definition proceeds by Boolean calculation:

\[
\text{bird} = (\text{sparrow} + \text{parrot} + \text{eagle} + \text{swan} + \text{hen} + \text{duck} + \text{turkey} + \text{goose}) = \\
\text{bird} \setminus \text{move} = \text{bird} \setminus (\text{fly} \lor \neg \text{fly}) = (\text{bird} \setminus \text{fly}) + (\text{bird} \setminus \neg \text{fly}) = (\text{sparrow} + \text{parrot} + \text{eagle} + \text{swan}) + (\text{hen} + \text{duck} + \text{turkey} + \text{goose}) =
\]


bird \cap \text{move} \cap \text{size} = ((\text{bird} \cap \text{fly}) + (\text{bird} \cap \neg \text{fly})) \cap (\text{small} + \neg \text{small}) = (\text{bird} \cap \text{fly} \cap \text{small}) + (\text{bird} \cap \neg \text{fly} \cap \text{small}) + (\text{bird} \cap \neg \text{fly} \cap \neg \text{small}) = ((\text{sparrow} + \text{parrot}) + (\text{eagle} + \text{swan})) + ((\text{hen} + \text{duck}) + (\text{turkey} + \text{goose})) = \\
\text{bird} \cap \text{move} \cap \text{size} \cap \text{color} = …

The summum genus is bird, the first differentia move is split to fly + ¬fly, giving subspecies flying bird and walking bird. The complete taxonomy forms a base for the Boolean algebra whose atoms are the infima species. A minimal basis is a free Boolean algebra in \( \log n \) independent binary features. Most times, the natural feature algebra is not free, and a tree of species arises.

<table>
<thead>
<tr>
<th>feature</th>
<th>species</th>
</tr>
</thead>
<tbody>
<tr>
<td>fly/true\cap small\cap brow</td>
<td>sparrow</td>
</tr>
<tr>
<td>fly/true\cap small\cap white</td>
<td>parrot</td>
</tr>
<tr>
<td>fly/true\cap big\cap brown</td>
<td>eagle</td>
</tr>
<tr>
<td>fly/true\cap big\cap white</td>
<td>swan</td>
</tr>
<tr>
<td>walk/true\cap small\cap brown</td>
<td>hen</td>
</tr>
<tr>
<td>walk/true\cap small\cap white</td>
<td>duck</td>
</tr>
<tr>
<td>walk/true\cap big\cap brown</td>
<td>turkey</td>
</tr>
<tr>
<td>walk/true\cap big\cap white</td>
<td>goose</td>
</tr>
</tbody>
</table>

An intensional definition in the taxonomy is a meet of a genus and a differentia like walking bird. But the taxonomy obviously supports disjunctive definitions quite as well.

**Prototypes**

By prototype is meant a central or optimal concrete extensional instance of a concept (Rosch 1973), which satisfies the intensional stereotype of the concept, i.e. focal clues for membership in the concept (Putnam 1976). A sparrow is a prototype bird, exemplifying the stereotype of a smallish two-legged feathered winged beaked flying animal.

A definition by prototype is nonmonotone: a bird is like a sparrow, except that it need not be small (eagle), fly (hen), or be brown (parrot).

My point here is that the prototypical form of definition makes literal formal sense in Boolean algebra quite as much as the traditional one. In particular, it does not yet entail loss of crispness (two-valuedness) of concepts.

The second dual of a Boolean algebra is isomorphic to it (Halmos 1974:78). An element of the original algebra corresponds in the second dual to the set of elements which include it, or the Boolean filter generated by it. In Leibniz’ terms an individual is the set of all of its properties.

The object type like sparrow can be taken to denote the filter of neighborhoods of the image of sparrow in the dual algebra, i.e. the sets of properties which meet the set of properties of sparrow. The natural subset topology of this set defines a partial order of nearness to sparrow by the number of shared properties. The species nearest sparrow in the taxonomy of the previous section is small brown flying bird, which identifies sparrow itself. The species next to it within the genus bird are those which abstract one feature, namely small brown bird, small flying bird, and brown flying bird.

The object type like a sparrow but does not have to be brown denotes the object type obtained by going over to the dual algebra, where the dual of the meet bird/\cap fly/\cap small/\cap brown is the sum of features bird/\cap fly/\cap small/\cap brown, subtracting brown from it to get bird/\cap fly/\cap small, and taking a dual back, which gives the type bird/\cap fly/\cap small flying bird. This operation cannot be expressed as a Boolean function of the terms sparrow and brown, for it depends on the base of features implied by like. (Compare also sections on atoms and on except.)

Once one leaves is the ideal of monotone definitions, one can countenance categorisations which form nonmonotone chains of family resemblances (Taylor 1989, Wittgenstein. They combine the two dual directions of categorisation, now adding, now subtracting cases: This is more or less how people proceed when they are not educated about taxonomies. It also recapitulates evolution of meaning in language.
The subset topology of *like* can be refined by having a metric on features. For instance, measure features in information theoretic terms by the number of individuals they exclude. This is an additional, independent innovation of prototype theory to classical definition. It is the idea that membership criteria are not binary, but comparative or metric, and consequently category membership is graded or fuzzy. The thought is close at hand given the natural topology of *like*, but it is separable. Dahl’s (1985) formalisation of prototype category involves partial order (an inclusion lattice). The fuzzy category approach (Zadeh 1978) maps category membership on the reals.

**Typology**

Comrie (1985:19) recommends distinguishing central (prototypical) and secondary meanings of tenses in addition to, or instead of, abstract schematic meanings. The relations between prototypical or focal meaning and the more traditional notion of basic, abstract or schematic meaning (*Grundbedeutung, Gesamtbedeutung*) have begun to become clearer with cognitive grammar (Langacker 1987, 1990, Taylor 1989, Sweetser 1990, Smith 1991). As tools for logical inference, they are of different value. Schematic meaning, as the covering concept or intersection of the entailments of all individual uses, approximates meaning from above and supports deductive inference. Prototypical meaning approximates meaning from below, and supports default inference, a type of inductive inference. Although defeasible, default inference is key to efficient communication, as it allows drawing conclusions in context from the absence of premises.

Dahl (1985) proposes a methodology which crucially involves the notion of a TMA prototype. His program is as follows. Choose a number of contrasts which are known to be associated to tense and aspect distinctions in various languages. Study the clusterings of such contrasts across languages and define on the basis of the clustering TMA prototypes like perfective, imperfect, progressive and their special cases. The special instances, or uses, of a prototype are different combinations of criterial features associated with the prototype. Subsets of features are partially ordered in terms of dominance so as to form a lattice of *more or less* typical instances of the prototype. Characterise the TMA system of each language as a selection of prototypes, possibly narrowed down as per language to special cases.257

Dahl’s methodology is inverse to the one followed here. Dahl defines meanings bottom up, my approach is top down. I start out with basic distinctions that are neutral with respect to clustering and which define tenses and aspects categorically. If two languages have different types of perfect, the definitions of perfect in the languages are different. At the same time, they belong to the same category by being instances of a common definition (e.g. existential and result perfect). Relations of markedness (if I have chosen primitives and definitions judiciously) are reflected in the complexity of the definitions.

Are the two approaches *incompatible*? I do not think so. Dahl defines a prototypical TMA category as a lattice, or a partially ordered disjunction of conjunctions of features, representing alternative specifications of a vague concept. This way to define a tense or aspect prototype is consistent with mine. It helps explain the clustering of the special cases within the common prototype. What it left to explain is why just given clusters of features should be preferred. That is what I try to capture by looking for conjunctive definitions covering preferred extensions of the prototype. But we can have both: a TMA category can be simultaneously approximated intentionally from above as a conjunction of properties and extensionally from below as a disjunction of special cases. Elimination by paradigmatic contrast is yet a third method, also compatible with the Boolean logic of the formalism.

Many examples of focal vs. peripheral meaning contrast the general case to singularities: a degenerate or boundary cases. There is a simple majority or weighted sum rule behind this: the more of the common (criterial or accidental) properties of a class an instance has, the further it is from the boundary of the class, the more prototypical and focal the instance.

An example of prototypical or focal meaning is the default interpretation of the progressive. My definition of the progressive does not specifically require that a progressive is restricted to denote the interior of an event. However, in the absence of evidence to the contrary, this is prototypical of the progressive. *I am working on it* suggests I started work earlier and will go on for a while. In my view, these implicatures follow because the prototype or focal case of *part is proper part*, specifically *interior part*.

There are tools already in the calculus for formalising these observations. We can use priority operators to order the range of the progressive as follows:

\[
\begin{align*}
\text{prog } e &= \text{in } d \text{ of } e \\
in d &= x: d \cap x < \cup? x: d \cap x < \\
d &= p \cup? s
\end{align*}
\]

---

257Dahl 1985 does not actually carry out the program in full (there are no lattices of features defined explicitly for TMA prototypes).
This says that the prototypical progressive denotes a process properly nested within e. Less focal progressives allow dynamic or temporary states at the edges of an event. The priorities show in typological markedness, direction of development, and preference among contextual readings.

Another example is the default interpretation of closed events as atomary. A point is a prototypical example of a closed set. Having an interior is not a necessary feature for a closed set, while it is a defining property of the contrary notion of an open set. Hence, unless otherwise indicated, a closed event is an atomary one.

\[
\text{open} \rightarrow \sim \text{atom} \\
\text{closed} \rightarrow \text{atom}
\]

Another example is the tendency to understand an open event located in a span of time to fit it tightly inside a time but loosely around it, while a closed event fits loosely inside a time but tightly around it. This is predicted, for open and closed events are dual. (See chapter on time adverbials.)

The principle here is the Gricean maxim of quantity. \(Ceteris paribus, p \rightarrow q\) implicates \(p \leftarrow q\), which means it entails \(p \leftarrow ? q\). I don’t like it allows I am indifferent about it but implicates I dislike it. Not believe implicates believe not. I did implicates I don’t/won’t.

The last mentioned exclusion explains how I used to run comes to mean I don’t run anymore or I (had) thought it was rather small implicates I have changed my mind. I slept badly last night implicates I slept badly most or all last night. I woke up twice implicates I did not wake up a third time. Such implicatures depend on the topic of the dialogue. I had a dream last night need not implicate I had only one, if the topic is that dream, not how many I had (Carlson 1983).

A third case in point are differences in focal cases between tenses and aspects of different languages which represent the same schematic category, for instance simple past and perfect. Although simple past by definition can extend up to the present, the focal meaning of a simple past is proper (remote) past, because that is where it contrasts with the perfect and the present. Although both English and Finnish can say I was born in October/synnyin lokakuussa, Finnish also allows existential perfect olen syntynyt lokakuussa here, and this makes the Finnish simple past a specifically narrative tense here.

**Optimality theory**

Recently, a general theory of markedness has been proposed under the name of optimality theory (Prince and Smolensky 1993). Optimality theory views grammar as an optimisation problem.

Karttunen (1997) and Gerdemann/Noord (2000) develop computational implementations of optimality theory in terms of regular transducers and priority. Since the event calculus accommodates regular transduction as a special case, their constructions fall within my purview.

Priority meet extends analogously.

**Lenient composition** (Karttunen 1997) is defined as the priority join of composition and identity

\[
p:x \cup x:x \text{ or equivalently, } x:x \not\cap p:x
\]

and read \(p:x\) if possible. The latter idiom allows writing a sequence of lenient compositions of transducers as a sequence of priority meets.

The priority iteration operator \(^7\) allows expressing the preference relation involved in counting constraint violations. For instance, the famous Prince and Smolensky syllabification problem is formalised by the regular priority event type

\[
generate \circ? \text{ haveOnset }\circ? \text{ noCoda }\circ? \text{ fillNucleus }\circ? \text{ parse}\circ? \circ? \text{ fillOnset}
\]

Priority iteration of the parse constraint makes sure that the candidates with the fewest unparsed segments are preferred. Priority iteration defines counting or sorting, which is not a finite state notion.

Gerdemann/Noord (2000) replace sorting and counting with permutation and matching. This does not eliminate the constraint, but solves a different set of cases by going to the dual.

**Metonymy and metaphor**

Metonymy and metaphor are dual. The development of meanings can involve successive steps of abstraction and specification in different directions (Langacker 1987: 371-373). Jakobson (1956) pairs the traditional tropes of metonymy and metaphor with the structuralist duality between paradigmatic (disjunctive) and syntagmatic (conjunctive) relations in language. Metaphor is literally a translation: it transfers meaning through a common schema.

---

258 There is no way in a finite-state system to express the *general* idea that fewer violations are better than more violations (Karttunen 1997). The language \(u:v\) of lexicographically (alphabetically) ordered strings \(u<v\) in a given alphabet is not regular. In a one-letter alphabet, it yields the well-known context free language \(a^n \cdot a^n: m \leq n\).
or image. Metonymy works dually through a common instance, context or domain of the metonymy. The following
categorial diagram traces this dual relationship: In semiotic terms, metonymy involves symbols (extensional, external
relations) while metaphor involves icons (intensional, internal relations).

In this diagram, metaphor involves a shift of meaning from \( e \) to \( f \) via a shared *image* (schema) \( e \cup f \). Metonymy is the
shift of meaning from \( e \) to \( f \) via a shared *instance* (context) \( e \cap f \). The arrows are morphisms of event types. Morphisms
are *iconic*, structure preserving mappings between structures. In category theoretic terms, morphisms between \( e \) and \( f \) on
a shared image \( e \cup f \) are arrows of the *slice category* over \( e \cup f \) (Barr/Wells 2002), metonymies are arrows in the category
under \( e \cap f \).

Looking for a shared schema is what is known as *generalisation* in unification theory (or *limit* in category theory): find
an abstraction which applies to both members of the comparison. The metaphor imposes an analysis on both members,
and allows a transfer of information from one member to the other through extension of the mapping between them
(called *stretching the metaphor*). That, incidentally, is precisely what this essay is doing: stretching the analogy
between formal language theory and aspect.

Abstraction leaves out content. Specialisation adds content to expression from its context so that the expression carries a
larger share of the common contribution. For instance, in the metaphor *leader is head* the move from *head* ‘animal head’
to ‘first’ which abstracts the image *first* by abstracting away the context *body* is a generalisation, while the further move of
*head first* to ‘leader’ which conventionalises the context *group* to the image *first* is a specialisation. The former
abstracts away meaning through contextualisation, the latter conventionalises additional meaning through
decomtextualisation.

\[
\begin{align*}
\text{body} & \rightarrow (\text{head} \leftrightarrow \text{first}) & \text{group} & \rightarrow (\text{first} \leftrightarrow \text{leader}) \\
\text{The metaphor } & \text{leader} \rightarrow \text{head} \text{ is the missing morphism which makes the diagram } & \text{leader} \leftrightarrow \text{group} \rightarrow \text{body} \text{ commute.} \\
\text{A contextual meaning becomes conventional when it no longer follows from, i.e. varies with, the context. A particular} \\
\text{reading becomes an item of the lexicon or grammar of the language. Essentially, what is at issue in such reanalysis is} \\
\text{associativity: associative relationships including Booleans, concatenation and function composition all allow a variety} \\
\text{of alternative decompositions.}
\end{align*}
\]

Metonymy is analogous to unification or category theoretic colimit. A part of a larger situation is taken to represent
another part of the situation (*pars pro toto*). A king as a prototype ruler has a crown and a government has a king. The
metonymy is a *locus of neutralisation* where crown gets to mean government.

\[
\begin{align*}
\text{king} & \rightarrow (\text{crown} \leftrightarrow \text{rule}) & \text{king} & \rightarrow (\text{rule} \leftrightarrow \text{government}) \\
\text{The metonymy } \text{rule} \rightarrow \text{crown} \text{ is the missing morphism which makes the diagram } & \text{crown} \leftrightarrow \text{king} \leftrightarrow \text{rule} \text{ commute.} \\
\text{TMAD meaning changes are metaphorical when a common schematic meaning is transferred from one domain to} \\
\text{another, and metonymical when focal meaning shifts from one feature of a prototype to another. (Bybee et al.} \\
\text{1994:196). Many are instances of both at once. For instance, be going in I am going to sleep may be true in both literal} \\
\text{(spatial) and transferred (temporal) sense at once.} \\
\text{Take a typical metaphoric future I am going to die. Literally, go has the structure of a mapping from time to place x at} \\
p.x.at \text{ q. The universal element of the metaphor (its greatest common content) is the notion of a graph, a continuous} \\
\text{mapping between two ordered spaces. The space-time metaphor instantiates the codomain of the mapping as the order} \\
of events: I am alive (at life) now, and I will be dead (at death) later. There is a simultaneous metonymy as well, for the} \\
\text{new mapping holds of the same situation.}
\end{align*}
\]
Finnish uses the opposite perspective *tulee satamaan* 'rain is coming'. This perspective comes naturally in impersonal or passive constructions where the subject is a patient or recipient: events are coming at us instead of us going to them. A passive perspective to events crops up in many other corners of Finnish grammar as well.

Bybee et al. (1994:297) associate different mechanisms of change with different stages of grammatical development. Metaphor is an early lexical device, metonymy a late grammatical one. New constructions are compositional, hence transparent. Compositionality is lost through short-circuiting, i.e. compilation of the composite function into an equivalent but more efficient noncompositional one.

For instance, reduplication is typically recruited as an icon of iteration Following familiar developmental paths, it can end up on either side of the open-close distinction. Greek and Latin reduplicative perfects: the former open, the latter closed, are an example.

Markedness and prototypes also involve iconicity, or structural correspondence between semantics and morphology (Jakobson 1965, Chung/Timberlake 1985).

Given closure of regular expression under homomorphism, metaphor and metonymy among objects of the calculus can be given an algebraically sound explicit representation, for instance as transductions.

For instance, the bleaching of I am going to sleep *I ∩ here ⟨ awake ⟩ ∩ I ∩ there ⟨ asleep ⟩* to a near future results from applying a place erasure homomorphism $∅^*$: *here*|*there*, which leaves over just the temporal meaning $I ⟨ awake ⟩ ^* I ∩ asleep$. One can think of a theory of bleaching which codifies such erasure morphisms.

### Meaning and implicature

"The failure to distinguish between meaning and implicature is one of the main problems in working out an adequate characterisation of tenses (Comrie 1985:28)." Garey (1957:92), Holisky (1981:129) and Matthews (1987:127) rightly take aspect studies to task for not considering minimal pairs, but positing different uses for contrasts which involve different contexts. This always leaves open the possibility that it is not the form (alone) but the context that accounts for the contrast (Sørensen 1964).

A related frustrating feature of many traditional grammars are turns of phrase like *may also express or often means* (Diver 1963:142). Not that this work is free of them. Such phrases are followed by selected illustrative examples but the contexts e for which the claim is valid are not circumscribed (for examples, see e.g. Curne 1931:Ch.XIX). It is left for the discerning reader to figure out why and when the implicatures hold. Fortunately, as the mechanisms generating implicatures are universal, one can often map foreign impressions onto vernacular ones and manage quite well using one’s native implicit logic. This requires human intervention, and will not do for a theory which aims at full explicitness.

When one says in aspectology that one thing *may mean* another, one is saying that the former *contextually* entails the latter. Given a theory of contexts, such statements become redundant corollaries. My aim in this work is to build such theory, in order to make special meanings formally derivable.

The common form of argument to distinguish inherent from contextual meaning of an aspect is intersective in character: given a claim that an aspect has such-and-such basic meaning, look for a context which fails to entail or contradicts the basic meaning, to show that the basic meaning is not there.

McCoard (1978) formulates the Padoan principle applied:

inferences mentally associated with assertions in particular contexts (only - L.C.) are not part of the structural meaning of the verb form employed in those assertions.

The principle is true but misleading. It is true that a form can only entail what is true of all of its uses. This does not prevent a form from essentially contributing to occasional meanings (if you change the form, the occasional meaning changes predictably). Inferences *de absentia* are nonmonotonic.

Trivially, a textual addition need not be semantically additive. fi *Luin tämän kirjan* 'I read this book (acc) entails I read all of it. This is in no way contradicted by the addition in fi *Luin tämän kirjan puoleenväliin* 'I read this book (acc) halfway (ill)'. These are different sentences. The application of McCoard's principle must be restricted to cases where meaning is arguably monotonicly increased. Even discourse does not automatically qualify, for there are corrective discourses: I *read the book. I mean I read most of it*.

Thus the argument should not overlook the fact of contextual reasoning that enriching context does not always add meaning, it can also nonmonotonically detract meaning, and vice versa. A critical addition or omission can rearrange the whole process of interpretation. (Recall the intransitive chains of counterfactual reasoning.)

Semantical thought experiments are a special case of hypothetical thinking, i.e. thinking in subjunctive conditionals. The task of interpretation is essentially a case of induction (or abduction) rather than deduction: search for the best explanation, or rational reconstruction, for a bit of discourse (Carlson 1983).
The logic of a subjunctive conditional differs from the classical conditional when antecedent \( p \) is inconsistent with context \( c \). The classical conditional becomes vacuously true but in the subjunctive conditional the context \( c \) jumps over to another salient context \( d \): ‘(I am not you but) if I were you, in which case such and such things would also be different, then... ’.

This type of hypothetical thinking explains why intuitions of meaning behave nonmonotonically. Strengthening an antecedent does not always preserve entailments. There is a background theory of the real world, including a theory of rational thought and action, which may suddenly change the context of the example to an entirely different one when more premises are added. The concept of focal meaning ties up with this idea. Focal or prototypical cases contribute to the metric governing the choice of salient contexts.

The concept of contextual meaning can be explicated using the concept of contextual equivalence and entailment. Contextual equivalence \( \sigma \rightarrow p \land q \) considered as a relation between \( p \) and \( q \) falls anywhere between tautology and logical equivalence, reducing to the first when \( \sigma \) is contradictory and to the second when \( c \) is a tautology. Contextual entailment is monotone if the context \( \sigma \) is constant.

Using the ideas from above, we can view the context not as an unstructured pool of premises, but as a strategy \( \sigma \) ordered by priority. Adding \( p \) to \( \sigma \) is not taking logical conjunction, but a priority meet, with \( p \) having the highest priority, and the rest of \( \sigma \) added to it in order of preference: \( p \land \sigma_1 \land \sigma_2 \ldots \).

Using this notion, Jakobson’s claim that (say) imperfective has a Gesamtbedeutung which accounts for all uses of that category (Jakobson 1932,1957, Smith 1991:92) can be made more precise: the Gesamtbedeutung \( p \) fully accounts for a use \( q \) where it is contextually equivalent to that use: \( \sigma \subseteq p \rightarrow q \).

Another consequence of the nonmonotonicity of contextual inference is that interpretation is not commutative. The order in which premises are introduced matters. This is a justification of sorts of a procedural description of the process of interpretation as proposed by DRT and similar approaches. However, though dynamic, the process of interpretation of a discourse is not mechanical. It is as complex as contextual inference can be.

For an example of contextual interpretation, recall It’s been hot (Mittwoch 1988:218) countered by It’s been hotter. The first one is felt to be a universal perfect, the second one an existential one. Why is there a difference? Because of the most salient completions (the ‘nearest’ possible worlds) are different. The first one is likely to mean it’s been this hot for some time, the second one it’s been hotter than this before. The other way round, It is still hotter than it is inconsistent, while an existential It’s been hot at least once as a discussion opener would be uninteresting. In the context It is not hot here emphasis on been does tease out an existential reading for It’s been hot.

A second way to fail McCoard’s principle plays on the concepts of basic meaning and context. There are two notions of basic meaning, an abstract or schematic meaning (the intersection of the entailments of all individual uses) and a concrete or prototypical one (Langacker 1987, 1990) which appears when an aspect occurs bare (or as bare as it can). A syntactic context may eliminate the prototypical meaning by adding a disjunct, thus making an occurrence fail to entail the prototypical meaning. The abstract schematic meaning is still entailed. (Perhaps one could say that the prototypical meaning is what the abstract meaning entails in a prototypical context.)

**Meaning by synonyms**

By one saying there is no such thing as a distinction without a difference. When any calculus makes two different expressions mean the same, the question remains why choose one of them rather than the other. Expressions which denote are free to connote different, taking a ride on the surplus of information left over by the redundancy (Shannon 1947). For this reason it is not indifferent which one(s) of a variety of different synonyms is chosen to convey a meaning. Though the meanings may match in a given context, they may diverge elsewhere, or bring in their different paradigms to play.

A good case of this are tautologous phrases like boys are boys. Closer to home, we have the use of reduplication to intensify: very very good is better than very good, however vague both may be. Two concepts may be vague enough for their domains to overlap or match entirely, but they can still have a definite relationship to one another. Fix one and the other one will mean different.

This is precisely the case with resolution. Although now can mean a time of any length, it has to be longer than right now and shorter than about now, as soon as we have decided how long it is.

Or consider the fact that open events like sleep satisfy the equation \( a = a^* \). In a given context, it still makes a difference whether I say sleep or sleep and sleep. Given the identity, any sleep and sleep is also a sleep; given continuity, the opposite is true too. But not without a difference: every application of the equation changes resolution. By using one form rather than the other I indicate the resolution applied. Sleep and sleep means a comparatively long sleep – long compared to sleep.

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259Lindstedt 1985:22 is a nice discussion of Gesamtbedeutung (usual meaning) vs. Sonderbedeutung (occasional meaning). Useful insights into vagueness (indeterminacy) and prototypical meaning Dahl 1985:3ff.
What I am talking about here is none other than Grice’s maxim of quality. By choosing how one says it one also indicates how one thinks about it, and hence what one means, without saying it. It is also the distinction between validity and a proof – between that and how one knows something is true.

**Misplaced meaning**

Despite these qualifications, the lesson of McCoard’s principle remains that most perceived properties of tenses and aspects need not be located in those forms at all, but in the interplay of forms with contexts.

There are many examples of the importance of avoiding misplaced meanings.

Smith (1978) can be criticised for confusing the time of before yesterday and that of yesterday in her treatment of Reichenbachian reference time. According to her, the reference time of Phyllis decorated the cake before midday (1978:49) is midday, so that the event time precedes reference time as indicated by before. This is at odds with Reichenbach’s definition of the simple past which makes reference time and event time coincide. It seems more correct to let the entire adverbial before midday denote the reference time.

Dahl (1981) considers toward the North Pole a potential terminal point. Yet, move toward the North Pole is imperfective. The resolution of this conflict is that the North Pole is a terminal point, but toward the North Pole is a direction (an open region).

Leinonen (1982) points out that the Russian perfective пропаль in On пропал два часа ‘she slept two hours’ does not entail the end of sleep. It is the two hours if sleep that end, not the sleep. This simple insight also helps understand the use of perfective with universal quantification.

Leech (1970) takes progressive to imply limited duration and is puzzled by examples like Death is getting nearer every day or He is always making fun of me denoting “ceaseless persistence of the process”. It is every day and always which imply ceaseless persistence here, while the progressive is consistent with it, at best implicating the opposite.

Diver (1963:150) along with many other writers groups universally quantified event types with iterative or habitual ones. I agree with Poutsma (1921:36), who deems it improper to extend the term iterative character to those forms of repetition which do not imply indefinitely prolonged iteration. There is no iteration operator in sentences like the following:

The brass band played each evening during the officers’ mess.

Universally quantified sentences of this sort can have perfective aspect in languages which make the distinction. The fact that a sentence entails an iteration does not mean it is one.

Many writers say that the perfect is used for making summaries of past events. But the simple past is used in summaries too (This year has been bad, but the year before was worse yet), so what is the difference? One is that the perfect makes summaries of past events up to now, so it does not matter exactly when the events took place. These two additional clauses reveal the schematic meaning of the perfect: it is an indefinite near past (extended now). The impression that the perfect is more of a summarising tense than the simple past can be exhausted in the fact that the perfect summarises the entire past up to the present.

Simple aspect is also said not to view events in their course, but summarise them, as contrasted to progressive which views them in their course (Johanson 1998:§7.2.2). This too is not an additional meaning but a restatement. There is no distinct meaning of ‘summary’ coded in simple aspect. An event type is a summary relative to another course of events it summarises. An event type which summarises a narrative matches the same period. A progressive denotes a shorter event than it refers to, while an event in simple aspect refers to what it denotes. Ergo, the simple aspect summarises what the progressive views in its course.

The distinction between closed remote (existential) and open near perfect becomes one of scope for frequentative event types (series).

My mother has changed my diaper many times.

In the beginning the Universe was created. This has made a lot of people very angry and been widely regarded as a bad move. (Adams: Restaurant at the End of the Universe)

Although each individual diaper change is a closed event in the past with a tangible result, the iteration is irresultative and not separated from the present.

**Impressions**

I suggested that the often quite vivid impressions and intuitive images associated with TMA forms are quite as predictable as other sorts of contextual entailments of logical forms. A complete theory of aspect should also entail aspect impressions. Here is a list of impressionistic terms from Bache (1985) for starters:
The following blow by blow account (Bache 1985:229) is an example:

Howard turns with his bottle, and goes back through the house. … The pink sodium lights shine in through its glass roof; this is now the only illumination. The place booms with violent sound. Dancers sway their bodies … The German girl in the see-through blouse has started, in a corner, with a group of men around her, to take it off. She lifts it upward, over her head, and it whirls in the air above them for a moment …

The simple forms feel neutral, factual, detached, self-contained, distant and blunt. Each sentence mentions an event which happens in its own now. The coherence of the course of the events, such as it is, comes from the walkaround/lookaround script.

Looking more closely at the adjectives, neutral, factual, detached and self-contained reflect the fact that no containment, overlap or succession between events and times is entailed by simple forms. The distant/close-up contrast has been derived from the connection between the topological difference (inside-outside) and projective geometry (near-far, large-small).

The blunt-tentative contrast follows from the imperfective paradox due to branching future. Simple tenses announce an event, where the progressives express what is in progress.

Impressions come to relief in contexts of aspectual competition (neutralisation). When there is little difference in truth value, one seeks a difference in implicatures. The following brings together a number of cases.

When/after (had) Ved (Declerck 1991):

<table>
<thead>
<tr>
<th>He left when I arrived.</th>
<th>leave\then\arrive\snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>He left after I arrived.</td>
<td>arrive\leave\then\snow</td>
</tr>
<tr>
<td>He left when I had arrived.</td>
<td>arrive&lt;r\then\leave\snow</td>
</tr>
<tr>
<td>He left after I had arrived.</td>
<td>arrive&lt;r\leave\then\snow</td>
</tr>
</tbody>
</table>

These are nearly equivalent, but not quite. When does not strictly entail after, though suggests it through the post hoc ergo propter hoc principle. In virtue of contiguity, when is more apt to suggest causal connection than after. After allows both right after and sometime after, but suggests the later when contrasted to when. The bound pluperfect after I had arrived takes the protagonist’s point of view in contrast to narrator’s free past after I arrived, which makes it more plausible that the protagonist timed his departure by my arrival.

The impression that the perfect is more of a summarising tense than the simple past can be exhausted in the fact that the perfect summarises the entire past up to the present.

Simple vs. progressive aspect of process: I coughed all night long. night\→\in cough* I was coughing all night long. night\→\now. Sweet says the progressive emphasizes duration, Poutsma says it is more vivid. My explanation of both impressions is the scale of observation times implied by the progressive.

A universal progressive sounds irritated or impatient, suggesting overdoing things. The feeling of interruption comes from the suggestion that the observations are not clocked by the events themselves, but by times when something else ought to happen (Jespersen 1949:§13.1.1, Palmer 1987:§4.3.3: “what is happening happens very often, but it does not happen at set times”). The impression of vividness of imparfait pitutesque was explained as the selection of particular points of reference for a running commentary of happenings around them.
Finally, there are impressions about literary style. The stagnant, impressionistic feel of Chekhov’s ‘imperfective telling’ is in part due to open, irresultative (generic or progressive) event types in main clauses and closed events in subordinate clauses (Jensen 1990:395): *Kogda vyshli v nastave, na nebe chut' brezhhilo* ‘When they came to the city gate the sky was faintly paling.’ Literally, the focus is on how things are, not what happens. Proust’s “pseudoiterative” use of French imparfait frames events as instances of recurrent, habitual sequences associated to places and periods in the narrator’s life (Genette 1980:121). Bakhtin (19??) notes the frequency of *suddenly* in Dostoevsky and its virtual absence from Tolstoy’s “chronotopes”. Steinbeck’s *Pearl* uses sequences of stills reminiscent of film cuts.

In sum: the point here is that the explanandum (the aspect contrast) is far simpler than its explanantia (the impressions). The complexity is not in the aspect, it comes from the environment, like the complexity of an insect society or the game of life.

Neutralisation

Contextual equivalence is crucial in the development of TMAD systems. Contextual equivalences are loci of neutralisation between related forms or meanings of the same form, places where reanalysis or “conservative restructuring” (Parsons 1990) can happen.

Cases of *aspectual competition*, or neutralisation, where the logical difference between two forms vanishes because different combinations of tenses and aspects (and moods) may produce equivalent formulas, are particularly interesting from a typological point of view. They show how languages can express just the same thing using quite different forms. What is more, they provide places where a historical restructuring of a TMA system to an alternative has a good starting point: the usage does not have to change while the underlying system does, producing changes elsewhere. An important area of neutralisation is the tricky area of the perfect. The Latin perfect *scripsi* ‘I wrote/have written’ (whose descendants are the Romance perfects) covers both English (result and existential) perfect and the simple past (Jespersen 1924:275).

Redistribution of meaning shifts the split between criterial and accessory features. It can be doubted whether such a split can always be made, but sometimes it can. As an aspect changes, what used to be corollary becomes focal and vice versa. Example: Definite tense and perfective aspect both entail contextual uniqueness. For the former, the criterial feature is cross-identification, in the latter, singularity.

Related to both markedness and neutralisation is the often cited generalisation that *past positive indicative main* clauses exhibit a maximal number of TMA distinctions. Absence of any one of the conditions is apt to neutralise distinctions. A functional explanation to this is that past positive indicative narrative is the most complex discourse type anyway. On the other hand, the statistical fact can probably also be summed up from individual typological generalisations and structural assumptions behind them. There are not just an arbitrary number of more distinctions made in past positive indicative main clauses after all, but certain specific ones recurring from language to language, which, for good individual reasons perhaps, are not available in other contexts. Chung and Timberlake (1985) discuss such generalisations under the name of temporal/aspectual space. They list three cases: (i) Imperfective/perfective distinction is more common in the past than in the other tenses. (ii) Iterative (habitual) aspect is more likely in the past than in the present. (iii) Progressive aspect is perhaps more likely to show up in the present than in the past.

The formalisation offered here has the advantage of making it possible to pinpoint such loci for aspectual change. There are different degrees of neutralisation, from full identity of formalisation to contextual (conditional) equivalence. Many pairs of forms are equivalent though they do not denote the same. Here is an enumeration of cases.

1. Imperfective and perfect aspect of acquisitions *stand, stay, remain, retain* can denote the same event: *stand = ipf stand = perf ¬stand.stand* (Bache 1985:224)
3. Simple and perfective aspect of process accomplishments *write, read, cover, spend* can denote the same event: *Sneg postepenno zametal/zamel dorogu* ‘The snow gradually blocked (ipf/pf) the road.’
4. An event type *e* that is homeomorphic with one of its nominal arguments *x* is a locus of neutralisation between aspect and countability: *On pil voda / On vyplil vody* ‘He was drinking the water / he drank up some of the water’.
5. A definite past *eƒthen snow* and perfective past *pf e<now* are equivalent:
6. A present perfect *e'rƒnow* is equivalent to a near past *e.now: I('ve) just noticed it.*
7. Simple past and existential perfect, formalised as *e<now* and *e've now*, differ only in focus (denotation).
8. Definite simple past and pluperfect differ only in point of view: *Before the war he had admired the British country gentlemen very much, wore English clothes, kept English dogs...* (Bache 1985:224)
9. Duality shifts are a locus of neutralisation between near and remote pasts. *He went out two hours ago* is conditionally equivalent with *He has been out for two hours.*
10. Cyclic events are a locus of neutralisation between past perfective and present perfect: *I already ate/I have already eaten. Ty provel/provodil chasy? ‘Did you have you wound up the clock?’*

11. Definite (indexical or descriptively unique) events are a locus of neutralisation between past perfective and present perfect. *We (have) brought you some flowers. I (have) forgot my mantra.*

12. Near past adverbials of duration are a locus of neutralisation between perfects and perfectives. *I (have) toiled hard for 80 years.*

13. Quantifiers *always/ever/never/once/twice* and aspectual adverbials *yet/already/still/again/just* are loci for neutralisation between the simple/perfective past and present perfect.

14. When a game has a solution there is a locus of neutralisation between agentive modalities and future: what one can, wants, may and must do coincide what one is going to do.

15. Iteration of idempotent modalities (*It is necessary that he should/permitted that he may go*) are loci of neutralisation for subjunctive.

**Evolutionary typology**

Recent research on grammaticalisation has brought to light many developmental pathways that TMA grams tend to follow. Many such results have proved to conform with, and thus confirm the logical typology entailed by the present calculus.

Cross-linguistic evidence of tense and aspect development suggests that universals of TMAD change can and should be stated on a very concrete level. A small recurring set of moves of lexicalisation, grammaticalisation, and contextualisation, through identifiable metaphors and metonymies are operative in these changes (Cohen 1989:§ 4.10.) Here is Dahl's (1998) picture of the core cases.

Bybee et al. (1994:90) attribute the striking similarities among tense and aspect forms across languages to the shared semantics of the lexical sources on the one hand (source determination and universal paths hypotheses of Bybee et al. 1994) and to similar functional needs on the one hand (relevance hypothesis of Bybee et al 1994). The former explain similarities among younger etymologically transparent forms, the latter similarities among older, etymologically opaque ones. The task for formalisation here is to help explain the succession from formal similarities and differences between successive forms or (rather), successive states of systems.

This suggests looking at evolutionary typology too from a logical or category theoretic point of view, as a system of morphisms between alternative systems. Bleaching, or leveling, is a morphism of categories. Introduction of a fresh metaphor is a morphism from the donor domain and an inverse morphism or refinement of the recipient domain.
Evolutionary typology of past tenses

The evolution of past tenses has been well known from historical and comparative grammar for a long time (Delbrück 1893, Jespersen 1914, Meillet 1921). Kurylovicz (1966:59) maps the process to four stages:

1. present state resulting from a preceding event e\now
2. event preceding moment of speech (with present results) e now
3. past event related to the moment of speech (antiority) e<\now
4. past event e<\now

Aspects appear prior to tenses in language acquisition and grammaticalisation (Frawley 1992). Temporal adverbs precede finite tenses. The first tense distinction is likely to be a remote/past near/present distinct. In the development of creoles from pidgins, a closed/open aspect distinction tends to turn into a past/present tense distinction. This basic developmental cycle in the past tenses is well attested (Trask 1979, Holden 1990, Bybee 1994). Resultatives arise as derivational nominals (result participles and gerunds); perfects get grammaticalised as periphrastic constructions on these and auxiliaries; and finally, perfects become simple pasts by losing their compositional identity and shifting focus from the present to the past.

It is common knowledge in aspect theory that perfects develop from resultatives (Nedjalkov 1988, Bybee 1994). Nedjalkov/Jaxontov (1988) and Kozinskij (1988) list differences between resultatives and perfects. These properties reflect what it means for a perfect to be a grammaticalisation of a resultative:

1. Resultative is derivational and lexically governed, perfect is inflectional and productive.
2. Resultative can change verb diathesis, perfect does not. Thus perfect co-occurs with manner adverbials (quickly, slowly, skillfully, deliberately) and directional adverbials; resultative drops some modifiers and changes the cases of others from directional to locative ones.
3. Resultative is open, perfect can be closed. Resultative allows still, perfect allows quickly.
4. Resultative denotes result state, perfect can denote event. (Near/remote) past time adverbials co-occur with (result/existential) perfect.
5. Result state of resultative is lexically defined, perfect allows looser current relevance (contextually determined or vacuous result).

Dahl (1985) reports that perfects are predominantly periphrastic while simple pasts are affixal. Lindstedt (1996) points out that perfects tend to be young and (because?) unstable. The development path of past tenses thus follows the general tendency of new forms to come in as compositional phrases and die out as lexicalised inflections.

Bybee, Perkins and Pagliuca (1994:54ff) divide senses of past tense and aspect forms into completive, resultative, anterior, perfective, and past. According to Bybee (1994), two major lexical sources of past tenses are completives which produce closed event types with dynamic phasal verbs of completion or closure ('complete/finish Ving') and resultatives which produce open event types from a result participle and stative auxiliary ('have/be Ved'). Both types go on to produce anterior (perfect) forms which in turn produce perfectives and simple pasts. The following table sets out their definitions and a suggested formalisation of the distinctions.260

<table>
<thead>
<tr>
<th>Name</th>
<th>definition</th>
<th>example</th>
<th>concomitants</th>
<th>sources</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>completive</td>
<td>change or action is completed</td>
<td>shoot someone dead, eat up</td>
<td>he went and ate it all up.</td>
<td>dynamic phasal verbs</td>
<td>~ss</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>finish, go, get up</td>
<td></td>
</tr>
<tr>
<td>resultative</td>
<td>state exists a result of a past action</td>
<td>he is gone</td>
<td>he is still gone</td>
<td>stative verbs</td>
<td>~ss's</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>be, have</td>
<td></td>
</tr>
<tr>
<td>anterior</td>
<td>result relevant to reference time</td>
<td>he has left</td>
<td>he has already/just left</td>
<td>completive or resultative</td>
<td>~s's</td>
</tr>
<tr>
<td>perfective</td>
<td>event is temporally bounded</td>
<td>he has been here</td>
<td>he was here once</td>
<td>anterior</td>
<td>~ss-s?</td>
</tr>
<tr>
<td>past</td>
<td>narrative past</td>
<td>he was here</td>
<td>he was here then</td>
<td>anterior or perfective</td>
<td>e then</td>
</tr>
</tbody>
</table>

Note that in Bybee et al. (1994) noun resultative is a past tense/aspect form (my resultative perfect), while my resultative as an adjective is the event type of a change. Bybee et al. anterior corresponds to my anterior perfect.
Table 80
Lindstedt (1996) also charts a development path from a compositional perfect participle construction to an inflectional
definite past. The following table is a combination of Bybee et al.’s (1994:105) and Lindstedt’s (1996) accounts.
Developmental time flows from left to right. Each cell can result from earlier cells touching it.

<table>
<thead>
<tr>
<th>Cell</th>
<th>Result</th>
<th>Resultative</th>
<th>Near Past</th>
</tr>
</thead>
<tbody>
<tr>
<td>r:q</td>
<td>cause r</td>
<td>e\r</td>
<td>e.now</td>
</tr>
<tr>
<td>(half-</td>
<td>anterior</td>
<td>indefinite perfect</td>
<td>definite past</td>
</tr>
<tr>
<td>closed)</td>
<td>e'r</td>
<td>e&lt;now</td>
<td>e\then &lt;now</td>
</tr>
<tr>
<td></td>
<td>e&lt;now</td>
<td>e&lt;now</td>
<td>e&lt;now</td>
</tr>
<tr>
<td>Completion</td>
<td>Completive</td>
<td>Perfective</td>
<td>Near Past Perfective</td>
</tr>
<tr>
<td>Ue</td>
<td>~e.e.~e</td>
<td>pf e</td>
<td>pf e.now</td>
</tr>
<tr>
<td>(closed)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 81
What formalisation can add to the business of charting the changes is more explicit consideration of just what
changed in each step. The variables are limited in number: input event type, output event type; open/closed/half-open,
near-remote, present/past focus, commutativity with other operators.

The formation of a resultative gram implies restructuring a perfect participle or phasal verb construction into a
compound tense/aspect for resultative event types. This typically involves loss of agreement in favor of fixed word
order. Similar structural changes happen when a completive becomes perfective. The step from completive or
resultative to anterior is marked by the extension of the construction from resultative event types to all event types.

The step from anterior to indefinite perfect weakens lexically defined result state to contextual current relevance. The
form is still about now but all that is implied about now that the event is past. The step to definite past/past perfective is
a shift in focus from the present to the past. Other development paths are possible, e.g. from an anterior to a near past
perfective pf e.now (Bybee et al. 1994:87) or a simple near past e.now (Lindstedt 1996). The direction of development
is toward less morphological and semantic markedness, i.e. simultaneous loss of distinctions (unidirectionality and
parallel development hypotheses of Bybee et al. 1994).

The chart ought to be extended to consider the surrounding system. New forms create new sediments which mutually
influence existing ones. (the layering hypothesis of Bybee et al. 1994). For example, Bybee et al (1994) suggest that the
development of an anterior into a perfective (French) or a simple past (German) depends on the prior presence or
absence of a past imperfective (Johanson 1998). Unless imperfective is marked, perfective cannot develop from
anterior. Habitual aspect is often an unmarked form, an old unmarked present squeezed to generic contexts by a new
progressive.

Johanson (1998:§8.7.8.10.2) observes that the loss of auxiliary from a compound perfect developing into simple past is
associated with the shift of focus from the reference time of the auxiliary to the event time of the main verb. Ellipsis of
repeated auxiliaries in sustained (third person) narrative may play a role here.

Perfec ts come about on half-closed event types and they are the first to shift into simple pasts. Cycles and open event
types linger on longer both coming and going (Johanson 1998:§8.10.2).

Evolutionary typology of perfect
A number of languages which have an intransitive be perfect (Finnish, German, Bulgarian) allow definite past time
adverbs with the present perfect, while a number of languages which have a transitive have perfect don’t (English,
Danish, Spanish, Portuguese). Of course, grammaticalisation may mix up the sediments so that anything may end up
going with anything. French passé composés with avoir look like have perfects but act like the past perfectives with
être. But fresh be and have perfects are different: have perfects are passive and resultative, be perfects are active,
perfective, experiential, and evidential. This agrees with the compositional origin of the construction. (Johanson
1998:§8.8). Consider more cross-linguistic evidence.

Greek has two participles, one from a perfective (aorist) stem and another from a perfect stem. The gloss for a
perfective participle nikesas is ‘one who wins/won’, while a perfect participle nenikemenos means ‘one who is beaten’.

261 There is a difference in how the extension happens in open event types (Bybee et al. 1994:76): the resultative of a
state like white is likely to be coerced to an inception has become white, while the completive of a state is more apt to
obtain a nontemporal sense is completely white.
Actually, neither participle is unambiguously past. The perfect participle denotes a result state, which is past for closed events but simultaneous for open events. The perfective participle denotes a closed event. It has its own definite reference time which is not fixed relative to the reference time of the head. It sometimes translates as a present participle, sometimes as a perfect one. While the present participle (citing Kühner 1896;§389) “die Handlung in ihrer Entwicklung darstellt” and the perfect participle “die vollendete handlung in ihren Wirkungen fortbestehend ausdrückt”, “bezeichnet jenes (the aorist participle) dem Momentanbegriffe des Aorists entsprechend dieselbe blossom as Handlung gleichsam begebenheitlich”.

Kühner (1966;§389, Anm. 8) sums up the generalization as follows:

Gewöhnlich wird das Partizip des Aorists von einer vergangenen Handlung gebraucht, weil eine von der Haupthandlung sächlich verschiedene Nebenhandlung, die als momentan aufgefasst wird, in der Regel nicht als neben herlaufend (gleichzeitig), sondern als vor ihr abgeschlossen erscheint. Dass aber das Partizip des Aorists entsprechend seiner zeitlosen natur auch von momentan gleichzeitigen Handlungen gebraucht werden kann, beweisen viele der oben angeführten Beispiele. Insbesondere ist dies der Fall, wenn die Nebenhandlung nicht sachlich verschieden ist von der Haupthandlung, sonder nur eine Modifikation derselben darstellt.

Thus homologesan Athenaiois teikhos kathelontes means ‘They yielded to the Athenians and took down (taking down) the wall’, i.e. showed good faith by/in taking down the wall. The wall was probably taken down after signing a treaty, if that matters. In prosleisas de apeuda ‘He said, by way of making a threat’, simultaneity (redescription) is the best bet. Anterior timing is imputed in kataklambanousi Brasidan epeleuthota ‘They capture Brasidas on arriving’.

This suggests that an active intransitive perfect participle is perfective (an existential perfect) whereas a passive transitive one is resultative (a result perfect). A perfective participle allows past adverbials (because it denotes a closed past event), while a passive perfect goes with present adverbials (because it denotes a result state). The two pair up nicely in Greek Perseus men ekhei kai nenikemenos tous paidas, Aimilios de tous autou nikesas apebalen ‘Perseus has got his children though he is/has been beaten, but Aimilios lost his though he won.’ The first clause is about the present state, the second one about a past event. The the first one has a passive participle, the second one an active one.

A connection between diathesis, aspect, tense, evidentiality and discourse function appears here. A passive perfect is resultative, open, near past, specific, and about the object and the present. An active perfect is irresultative, closed, remote past, evidential, and about the subject and the past. The causal analysis of transitivity in the section on diathesis forges the link. An active perfect basically says that the cause of a transitive event (what the subject did) is over, while a passive perfect says the effect (what happens to the object) holds. From this point of view, the active predicative perfect is concerned with the experience of the subject, the passive possessive perfect with the result state of the object. In the process of becoming past tenses, passive perfects are found to develop from passive through ergative to active diathesis. (Kurylovicz 1964:56-89, Comrie 1976;§4.6)

For example, the Bulgarian present perfect is formed by the present tense of the auxiliary sam ‘to be’ and the active aorist participle of the main verb, e.g. sam napravil ‘is one who did’ (Lindstedt 1985:65). This form accepts past time adverbials: Pratkata e pristi tri dena ‘The delivery (has) arrived three days ago’. So does Finnish Lähetys on saapunut kolme päivää sitten ‘The delivery (has) arrived three days ago’, where on saapunut can be glossed ‘is one which arrived’. Lindstedt (1996) claims that the Bulgarian perfect has existential but no result or current relevance uses. This is consistent with my proposal.

Bulgarian also has a have Ved construction which may be progressing toward a transitive perfect. imam gi napekatan can mean ‘I have printed them’, ‘I have had them printed’, and ‘I have them printed’. Lindstedt (1985:69). The Bulgarian transitive perfect still feels awkward if the result is not in the possession of the subject: I have bought them (have bought them) is good but I have sold them (have sold them) is not: if I have sold them I don’t have them (Lindstedt 1985:69). Macedonian has developed a similar nonevidential passive possessive perfect ima resheno ‘have decided’ which becomes evidential with the active past participle imal resheno (Cohen 1989:139).

Comrie (1981:72-73) cites evidence from Armenian. Armenian has two perfects, an active perfect participle and a passive resultative one. The perfect combines perfect meaning with perfective meaning, that is, refers to a state resulting from a single event that took place in the past, whereas the resultative can combine perfect meaning freely with other aspectual parameters (aspectsitually, it produces a state). Comrie (1981:70-71) proposes an explanation of the correlation: a passive resultative perfect produces a change of state in the object, while an active perfective perfect entails no such change. This also suggests that an active perfect might be more apt to become an indefinite past or evidential.

Given there in fact are two opposite directions to arrive at a perfect, it is not surprising that there should be different camps on what a perfect really is (existential vs. result perfect). Some languages only have one or the other, others have different forms for the two (Dahl 1985:139). The following sections attempt a logical reconstruction of these empirical findings.

**Be**

A source of intransitive perfects is a predicative construction on an active intransitive past participle be gone:
I am gone. I be x:here,¬here\s(x)

This is a resultative perfect in that the result state of gone (away) is an atemporal state of the subject. Passive (see a film) and reflexive (read a book) transitives form an intermediate case here, for here, the event may or may not leave an atemporal trace in the subject. But consider the be perfect of a causative transitive as the Finnish

Olen kaatanut puun. ‘I have (lit. am) felled (act ptc) a tree.’ I be x:p(x) cause fall(tree)\w(x)

Here, the result state is an atemporal property of the tree (say, being in two pieces and lying down). For the definition of fell it is immaterial what changes may have taken place in the agent; most likely, they are accidental and reversible (getting hot and tired, having a sense of accomplishment, remembering doing it). In the last analysis, the only noncancellable result of causing an event is the occurrence of the event itself. Consequently, s(x) above is the state e¬\s\r, which equals pf e\r which equals e\r. To sum up the argument: an active perfect of a causative transitive becomes a perfective or existential perfect.

Have

A common source of transitive perfects in European languages\(^2\) is a possessive construction on a passive transitive past participle have something done (Traugott 1972, Bybee et al. 1994:68, Nedjalkov 1988, Cohen 1989, Parsons 1990). Have is etymologically the causative of be, meaning cause to become/stay in (one’s possession), which fits the common etymology of ‘have’ from ‘hold’. The shift from the prototype ‘cause to stay in one’s hands’ p(x) cause y be in hands of x to ‘have’ y be in p of x essentially abstracts away the cause, leaving the result state, and contextualises hands of x is into an arbitrary binary relation abstract y\r(x,y) filled in from context.

\[
\begin{align*}
\text{d(x) cause y be in p of x} \\
\text{σ → d(x)<} \leftrightarrow <y \text{ be in p of x} \\
\text{x=x ≤ y be in p of x} \\
\text{y be y:}\text{r(x,y)} \\
\text{r(x,y)}
\end{align*}
\]

The shift in meaning which produces the have perfect can thus be mapped as follows:

I have the tree felled. p(I) cause tree be y:q cause y fall\r(y)
I have felled the tree. I be x:p(x) cause fall (tree)\w(x)

The following shifts take place. First, the subject of have binds the free agent variable of felled: I have the tree felled by me, telescoping the factitive passive into an active transitive. The asymmetry of time justifies this step. Since past cannot be changed, the claim that I am responsible for the tree staying fallen can only mean that I am responsible for it becoming so, i.e. that I caused the tree to fall. If I am alone responsible, the conclusion is that I felled the tree: p(x) cause tree become y:q cause y fall equals p(x) cause fall(y).

Third, the sentence becomes one about the state of the subject instead of the object. This is a legitimate topical lambda conversion, justified by the grammatical finite subject position of the subject of have. Summing up, a possessive resultative passive perfect becomes an active transitive perfect.

Combining this with the result of the previous section, we have a logical reconstruction of a chain of meaning shifts from resultative to perfective or simple past - a well known and multiply attested chain of changes. The preferences of the two perfects concerning definite past adverbials appear already at the etymological source of the constructions. A past adverbial Eilen ‘yesterday’ is fine in an intransitive predicate complement construction, while it is odd to have nyt ‘now’ in this construction:

Nuo pullat ovat (*nyt) eilen tulleita. ‘Those buns are (among those which) arrived yesterday.’
Pullat ovat minulla nyt (*eilen) leivottuina. ‘I have the buns all baked now (*yesterday).’

Conversely, nyt ‘now’ is fine while eilen ‘yesterday’ sounds out of place in the possessive resultative construction. The English perfect, etymologically a possessive resultative, does not allow past time adverbials. (In English Those cakes are baked yesterday seems bad too, showing yesterday fails to attach to a participle in English.)

Already

Dahl (1985:129) mentions already (‘as early as now, by now’) as a further source for perfects. and Palmer and Blandford (1939:149): “[the perfect] is more or less equivalent in meaning to the word already. They show that the action referred to by the verb is anterior to the moment or period expressed by the adverbial of time associated with the

\(^2\) Cross-linguistically, have seems a marked frame type (Dahl 1998). Many languages (Finnish, Russian) prefer an intransitive locative frame be in the possession of (with/at).
sentence,” and Frawley (1992:347). This agrees well with the fact that my analysis of *already* is just the perfect prototype. We noted in the section on aspectual adverbials how *already* turns a perfective into a near past. Já (até agora) *already (by now)* disambiguates Perfeito for present perfect meaning in Portuguese (Santos 1996). Russian *uzhe* *already* compensates the lack of a pluperfect (Dahl 1985:191, Timberlake 1982:312). The same goes for classical Arabic *qad* *already, by now* (Cohen 1989:127, 185) and Chinese *le* *by now*.

**After**

Comrie (1976:106) notes that Celtic languages (Welsh, Scots and Irish) form a perfect from synonyms of *after*, e.g. Welsh *yr ydwyf i wedi ysgrifennu'r llythyr* *I have written the letter, lit. ‘I am after writing the letter.*’ Yet another source for anterior tenses are movement verbs, in particular verbs meaning ‘go through’, ‘come from’ or ‘get up with’ (Bybee et al 1994).

Perfecteds are a common source for evidential quotative (reported) and inferential past tenses (Comrie 1976:110, Dahl 1985:149). We noted that perfect is indefinite about the event time, which (relative to acquaintance criteria) allows that the event was not witnessed: "je constate le résultat -> j'ignore le procès -> j'indique que j'ignore le procès -> que je me contente de le rapporter -> que je n'en prends pas l'affirmation à mon compte" (Cohen 1989:141). As Cohen notes, perfects arising from compositional participial periphrasis can thus follow two opposite lines of development: shift focus to the past event to become perfective (first hand narrative), or distance further from it to become evidential (second hand narrative).

**Evolutionary typology of imperfective**

Imperfective forms come from progressives and iteratives (Bybee 1994:158-9). Progressives arise from nonpast participles and locative adpositions (Cohen 1989:126), while typical exponents of iteration are pluralising derivational suffixes and reduplication. Perfectives develop from clausal perfects, bounding particles (prepositions and adverbs), and semelfactive (momentaneous) affixes.

These findings suggest a markedness typology of (im)perfective aspect. The unmarked aspect in a language can be perfective or imperfective (Heath 1981:101), or either depending on the Aktionsart. Unmarked perfectives may be more common (Friedrich 1974) already because the unmarked event type for verbs is closed, while adjectives are open (Langacker 1987). If perfective is marked, then aspect marking appears on verbs of open event type. The marking depends on the etymology of the construction and the morphological type of the language in predictable ways.

If imperfective is marked, then closed event types carry a marking. Given the favored sources of marking, imperfective forms are likely to be phrasal and/or carry a locative affix. The aspectual import of reduplication is can be iteration or result state (both open event types). However, along the developmental paths just listed, reduplication can end up on either side of the (im)perfective distinction (e.g. Greek imperfective *gi-gnomai* *‘be becoming’, perfect ge-gona ‘have become’, Latin perfective ce-cidi ‘killed’).

Mokilese (Chung/Timberlake 1985) is in good accordance with these predictions. It has a progressive marked by reduplication and a perfective marked by directional suffixes attached to the verb. Georgian (Holisky 1981) uses different methods for different Aktionsarten. Extended event types are perfectivised with bounding prefixes; for the rest, there are suffixal and suppletive alternations depending on inherent aspect type.

Chung/Timberlake (1985) summarise a number of typological tendencies in (im)perfectives as the following table:

<table>
<thead>
<tr>
<th></th>
<th>perfective</th>
<th>imperfective</th>
</tr>
</thead>
<tbody>
<tr>
<td>case</td>
<td>object in direct case</td>
<td>object in oblique case</td>
</tr>
<tr>
<td>agreement</td>
<td>object agreement</td>
<td>no object agreement</td>
</tr>
<tr>
<td>transitivity</td>
<td>transitive</td>
<td>intransitive</td>
</tr>
<tr>
<td>voice</td>
<td>passive</td>
<td>active</td>
</tr>
</tbody>
</table>

**Table 82**

These interactions are taken up in the chapter on diathesis. The last row is predicated on the common perfect>perfective development path. The alternative path perfect>state creates imperfective passives.

Slavic and Romance (im)perfective aspects behave differently with respect to logical operators. We have the following array of facts. Note that *not sleep at all equals for a time not sleep*.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Portuguese</th>
<th>open</th>
<th>ipf</th>
<th>was not asleep/usually did not sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>nã0 dormia</td>
<td>não dormiu</td>
<td>não dormiu</td>
<td>did not fall asleep,sleep at all,sleep for a time/has not slept</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 83

These differences can be assigned to the different scopes of the operators in the two languages. Russian aspect is within the scope of the logical operators, while Portuguese aspect applies to them. This correlates with morphological type. Slavic aspect is derivational and perfective marks phase, while Romance aspect is inflectional and the (im)perfective distinction shows perspective. Markedness relations are different too.

Progressive

Progressives evolve from present participles (Cohen 1989), gerunds and locatives (Jespersen 1949:§12, Anderson 1973, Comrie 1976:98-103, Bybee 1994:129-133) with support verbs of state or position (be, sit, stand, stay), motion (come, go, walk) or (other) activity (do). The development path proceeds from a locative construction through interior progressive toward a general imperfective covering iterative and generic uses (Bybee 1994). It starts out as a lexically governed construction for complex open event types (process accomplishments in particular), and spreads from there to simple and closed event types, to eventually become a grammatical aspect (Johanson 1998:§10.2.1.5, Bertinetto/Ebert/deGroot 1998).

Smith (1991:114) classifies progressives by the range of derived uses they can have. English progressive is relatively far advanced toward imperfective, with immediate (about to), future (going to), and generic (generally) uses. Chinese zai seems restricted to interior progressive.

Finnish progressive periphrasis olla V+mAssA 'be (somewhere) Ving' retains locative meaning (answers a where question).

Hän on tekemässä testamenttia. ‘He is drawing up a will.’
Hän on saamassa perinnön. ‘He is (about) to get an inheritance.’

With an open event (partial object), it indicates finer resolution (right now rather than now in general). With a closed event, it is a future or point progressive. However, unlike English progressive, it retains an implication of happening at a specific location (it answers a where question). It is awkward if the location of the event in progress is not the location of the subject. Progressive of future and generic event types like the following is thereby excluded:

Poliisi on pidättämässä epäillyt huomenna. ‘The police is arresting the suspects tomorrow.’
Syön tavallisesti kotona, mutta tällä viikolla olen syömässä ulkona. ‘I usually eat at home, but this week I am eating out.’

Opposite scoping is predictably possible:

Tänään aikaan huomenna poliisi on pidättämässä epäillyt. ‘At this time tomorrow, the police will be out arresting the suspects.’
Lounasaikaan olen enimmäkseen syömässä ostereita. ‘At lunchtime I am mostly out eating oysters.’
This week is odd, but At lunchtime makes sense. What these observations prove is that Finnish progressive has narrow (lexical) scope: only fut prog e and gen prog e are possible, not prog fut e or prog gen e as in English. What grammaticalisation does to an aspect is widen its scope, making it commutative with other operators of the event calculus.

German and mainland Scandinavian progressive periphrases are also lexically restricted in distribution. German war am Trinken denotes actual, not habitual drinking (Johnson 1998:§1.2.1.5).

Evolutionary typology of perfective

Russian aspect is lexical, a grammaticalisation of diathesis and derivation. This sets apart Russian, a lexical aspect language, from grammatical aspect languages like Portuguese. Russian durative adverbials appear as a rule with the imperfective, not perfective.

On vsju molodost’ bojalsja otca. ‘Throughout his youth he feared (ipf) his father.’ (Smith 1991:310)
Ja (*napisal pis’mo materi dva chasa. ‘I wrote a letter to my mother for two hours.’

In Russian, adverbial bistro ‘quickly’ takes imperfective meaning relative duration, i.e. speed (fast) or pace (lively) and perfective meaning absolute duration (in a short time). Slow speed medlenno is paired up with long duration dolgo ‘long’ and imperfective aspect.

Gradual adverbs go with both aspects. Imperfective appears with s kazhdoj sekunsoj ‘by the second’ (Timberlake 1982:314-315). Postepeno ‘gradually’ allow both scopings:

Postepeno telo opjat’ priobrelo/priobretalo gibkost’. ‘Gradually his body again acquired/was acquiring its limberness.’

Relative frequency adverbials take imperfective (Mønnesland 1984):

ru On obychno prixdid’ k nam vo vtornik. ‘He usually came (ipf) to us on Tuesday(s).’
ru Ego zhena redko ulybalas’ ‘His wife seldom smiled (ipf).’

Here Russian (together with Polish and Bulgarian) differ from Czech, Slovak and Slovene, which use perfective. Absolute frequency adverbials allow both aspects:

ru On pjt’ raz perechital/perechityval eto pis’mo. ‘He read (pf/ipf) this letter five times.’

As Dahl (1984) observes, open event types are different here. Both aspects are possible. In general, perfective variants of states do not pattern with perfections of other types (Johnson 1998).

ru On stojal na uglu s dvux do pjati. ‘He stood (ipf) on the corner from two to five.’
ru On postojal tam chas. ‘He stood (pf) there for an hour.’ (Dahl 1984:12)

Rather like Romance perfectives, the Russian productive aspectual prefixes po/pro/do ‘temporarily/through/to the end’ which close open event types are compatible with durative adverbials. po allows an object-like adverbial of time, pro requires one, do takes do ‘until’ adverbials. These prefixes are thus able to scope over the adverbial.

On prostojal na uglu celyj chas. ‘He stood (pf) on the corner a full hour through.’
Oni pozhili god na juge ‘They lived (pf) in the south for a year.’
Ona dozhila do vesny. ‘She lived on (pf) until summer.’

Csató (1994, cf. Johnson 1998:§9.5.2) points out differences between Russian aspect and resultativity in Hungarian which may index a difference in grammaticalisation. Hungarian result particles do not exclude a verb from progressive present reading, complement of phasal verbs (begin). Hungarian bounding particles behave more like English bounding adverbials. They do not block coercion (unmarked aspect shift) from closed to open event type, required for phasal verbs and imperfective present, which Russian perfective aspect does.

Finnish object marking does as well: Aloin lukea kirja/kirjan (loppuun) päivässä. ‘I started reading a book (acc/ptv) (to the end) in a day/daily.’ The result adverb loppuun has no effect. The partitive object reads ‘I started reading the book (to the end) in one day’, the accusative object is only allowed on the iterative reading ‘I started reading a book (to the end) every day’. Russian aspect goes one notch further than Finnish in that a relative frequency adverb cannot save a perfective complement: ‘I started reading one book per day’ (pf book/day)* must have imperfective aspect ja nachal chitat’/prochityvat’ po knige ‘za den’. (Johnson 1998:§9.5.2, §10.4.3):

fi Hän kirjoittaa yhden kirjeen joka päivä. ‘He writes one letter (acc) every day.’
uu Minden nap megir (pf) egy levelet.
ru On kazhdyj den’ pishet (ipf) odno pis’mo.
Portuguese (and many other Romance) time adverbs do not select event type the way the English or Russian ones do. Temporal adverbs are disambiguated by aspect rather than vice versa. The English locative and durative temporal adverbs for/in are both translated by durante, and do-a can be translated by the durative from-to or by the locative between, depending on aspect type.\(^{26}\) Portuguese quando glosses English when/while:

<table>
<thead>
<tr>
<th>PT</th>
<th>English equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>pt Ele escreveu o livro durante dois anos</td>
<td>‘He wrote (pf) the book in two years’</td>
</tr>
<tr>
<td>pt Ele escrevia o livro durante dois anos</td>
<td>‘He wrote (ipf) the book for two years’</td>
</tr>
<tr>
<td>pt Ele escreveu o livro do Verão ao Inverno</td>
<td>‘He wrote (pf) the book between spring and winter’</td>
</tr>
<tr>
<td>pt Ele escrevia o livro do Verão ao Inverno</td>
<td>‘He wrote (ipf) the book from spring to winter’</td>
</tr>
<tr>
<td>pt Os sinos das igrejas tocam as vésperas quando um grupo de raparigas do Exército de Salvação</td>
<td>‘The church bells were tolling (ipf) for evening service while/when a group of Salvation Army girls marched (pf/ipf) down Waterloo Road singing’</td>
</tr>
</tbody>
</table>

The distinction between absolute and relative frequency can be made with aspect in Portuguese (Santos 1996):

<table>
<thead>
<tr>
<th>PT</th>
<th>English equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>pt Ela comeu lagosta muitas vezes</td>
<td>‘She ate/has eaten (pf) lobster many times’</td>
</tr>
<tr>
<td>pt Ela comia lagosta muitas vezes</td>
<td>‘She often ate (ipf) lobster’.</td>
</tr>
<tr>
<td>pt Ele deu muitos livros às crianças</td>
<td>‘He gave (pf) a lot of books to his children.’</td>
</tr>
<tr>
<td>pt Ele davava muitos livros às crianças</td>
<td>‘He often gave (ipf) books to his children’</td>
</tr>
<tr>
<td>pt Ele saiu três vezes/saiu três vezes por dia</td>
<td>‘He went out (pf/ipf) three times (a day).’</td>
</tr>
<tr>
<td>pt Ele saiu há dois horas</td>
<td>‘He left (pf) two hours ago.’</td>
</tr>
<tr>
<td>pt Ele está fora há dois horas</td>
<td>‘He has been (pres) out for two hours.‘</td>
</tr>
</tbody>
</table>

This is a locus for neutralisation between perfective and perfect aspect. ‘He went out two hours ago’ is almost equivalent with ‘He has been out for two hours’ (cf. our discussion of (since) t ago).

Portuguese marks gradual approach on the verb, English on the preposition: deslocou-se a ‘moved to’ / deslocava-se a ‘moved toward, lit. was moving to’.

**Typology of conditionals**

To obtain a typological view of counterfactuals, let us take a closer look at the Portuguese mood system. Traditionally there are two nonfactual moods, subjunctive and conditional. The names reflect the difference between them: subjunctive is the mood of various nonfactual subjoined clauses, conditional is the mood of the (consequent of) a conditional sentence. Morphologically, the subjunctive has a six-way tense system (finite past, present and future, simple and perfect aspect). The (im)perfective aspect distinction is not made in the subjunctive. Subjunctive is a bound strong mood used in nonfactual contexts, in dependent clauses in the scope of nonfactual modals. Compare the use of should as a dependent mood in English in It is necessary/impossible that it (should) happen, I wished/fearred that it (should) happen. The present and past tenses of the subjunctive form a regular pattern in nonfactual dependent clauses. A weak bound mood called future subjunctive (resembling the Greek optative) is used in adverbial and relative clauses dependent on a future indicative or imperative main clause.

Se tiver dinheiro, pagarei (pago) amanhã ‘If I have money I’ll pay tomorrow’
Vais aprendendo à medida que fizeres. ‘You will learn as you go along’.

This is in accordance with a branching future model, where future is a modality and allows distinguishing between weak (may) and strong (is bound to) futures. The Portuguese future subjunctive can then in fact be neatly analysed s a weak future (note that it occurs in future conditional antecedents). Predictably, it is dispreferred in

Se isso vai/for machucar você, eu não faço. ‘If this will/should hurt you, I won’t do it.’

where the antecedent is not a future contingency (Comrie 1986:95). The Portuguese counterfactual conditional has a past subjunctive in the antecedent and a conditional mood in the consequent: Se tivesse dinheiro compraria livros. The conditional has a two way simple/perfect aspect distinction. Besides the consequent of a counterfactual conditional, it is used as a past future tense.

Comparing these facts to English and the picture above, the following rearrangement of Portuguese grammar suggests itself. Subjunctive marks nonfactual dependent mood as before. The conditional is a past future tense doubling as a hypothetical consequent mood (Thieroff 1994:28). When these stipulations are combined, the form of the Portuguese counterfactual conditional falls out.

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\(^{26}\)In contrast, Vlach (1993:245) notes that English has no terse way to locate both the beginning and the end of the time at which a closed accomplishment takes place.
The analysis of the Portuguese conditional as a past future is etymologically correct. The conditional is a half agglutinated word order variant of the Imperfeito of a near past tense \textit{tr+infinitive} ‘I was going to’. It even allows inserting the reflexive pronoun between the infinitive and the auxiliary.

| Eu ia comprar-o ‘I was going to buy it’ |
| Eu compraria-o ‘I would buy it’ |
| Eu lavar-me-ia ‘I would wash myself’ |

The Portuguese counterfactual conditional has a dependent tense/mood in the antecedent and a past future tense/mood in the consequent which also doubles as a past future tense. Many languages have counterfactuals which conform to the same schema (Lindstedt 1985:242). Here is a small survey:

| French: S’il avait (ind impf) d’argent il allait acheter/acheterait (past fut/cond) des livres. Il (a) dit qu’il allait acheter/acheterait des livres. |
| German: Wenn er Geld hätte (cond past), würde er Bücher kaufen. Er sagte dass er Bücher kaufen würde. |
| Dutch: Als je echt van mij hield (ind past), zou (past fut) je dat niet zeggen. ‘If you really loved me, you would not say that.’ |
| Swedish: Om han hade (ind past) pengar skulle (past fut) han köpa böcker. Han sade att han skulle köpa böcker. |
| Italian: Se avesse (subj past) soldi, comprerebbe (cond) dei libri. Disse che comprerebbe libri. |
| Colloquial Italian: Se aveva (ind impf) dei soldi, comprava (ind impf) dei libri. |
| Portuguese: Se tivesse (subj past) dinheiro compraria (cond) libros. Disse que compraria libros. |
| Colloquial Portuguese: Se tivesse dinheiro, comprava (ind impf) libros. |
| Classical Greek: Ei eikhe (ind impf) khremata, onesato an (ind aor) biblous/Ean ekhei (cond pres) khremata, onesei (cond aor) biblous. Ei ekhoi (opt pres) khremata, onesaito an (opt aor) biblous. Ephe hoti onesaito biblous. |
| Modern Greek: An eikhe (ind impf) khremata, tha agorase (fut aor) biblia. |
| Finnish: Jos hänellä olisi (cond) rahaa, hän ostaisi (cond) kirjoja. Hän sanoi, että ostaisi kirjoja. |
| Russian: Es’li u nego byli by (cond) den’gi, on kupil by (cond) knigi. On skazal chto on kupit/budet pokupat’ (ind pres/fut) knigi. |
| Bulgarian: Ako se obarnesheshe, stese da gi vidi. ‘If she turned around (impf), she would see (fut aor) them.’ |
| Hebrew: ‘Im hu haya ‘ose ‘et ze, ‘az hu haya matsliah. ‘If he had done (perf impf) it, he would have succeeded (perf impf).’ |
| Krio: A bin fo go (past fut) na Washington, if Jimi Kata go dong (fut past) lef de. ‘I would have gone to Washington, if Jimmy Carter had left there.’ |

Russian \textit{by} is an old past auxiliary (Leskien 1909§100). Modern Hebrew uses (what amounts to) a perfect of an imperfective in both clauses (Givôn 1982:135). Krio (a West African creole) has a past future (\textit{bin fo ’been for’}) in the consequent and a future past (\textit{go dong ‘go done’}) in the antecedent. Some languages use the same form for the antecedent and consequent (Finnish, Irish). American does (Joos 1967:124, Tedeschi 1981:261fn):

If this sleeplessness would have been allowed to go on, she would have been collapsed.

Its absence from standard English can be associated to the absence of \textit{will} from conditional clauses in general. Classical Greek has many different forms for nonfactual and counterfactual conditionals. The counterfactual conditional has past indicative mood. Nonfactual conditionals can have subjunctive or optative mood.\footnote{The Lezgian counterfactual conditional has a conditional past aorist in the antecedent, the main clause has a past future indicative. Some languages have no tense distinction, the same tenses translate \textit{If she were to arrive tomorrow, I would meet her at the station and If she had arrived yesterday, I would have met her at the station.} (Greek, Russian, Lezgian).}

In what Lindstedt (1985:241) calls a Balkan type conditional sentence, the conditional clause has an imperfective past tense and the consequent a past future. Lindstedt mentions parallels in Macedonian, Serbo-Croatian, Rumanian, modern Greek, and Albanian, even Sanskrit, Turkish, Garo, and Cree. There clearly is a typological universal here (Dahl 1985:146). Why are past and future tenses so universally used to express counterfactual reasoning? There are many suggestions in the literature. A recurring idea (Jespersen 1949§9.1.2) is that past and irrealis are both distant, remote in the sense of \textit{not here and now} and (unlike future) \textit{past our reach} (Lyons 1977). There is something to this explanation.

Small children treat \textit{yesterday} as the receptacle of all sorts of nonactual things, real or imagined, past or future. However, hypothetical reasoning is not a thing small children go in for.

Lindstedt mentions a more specific discourse based suggestion by Pasov: “if we use the irrealis ‘if he knew’, we have already said or thought that he does not.” The idea here seems to be that the past tense refers to a previous, rejected

\textit{should/were to} to mark a nonfactual antecedent: \textit{If he should/were to have money he would buy books}. 
position in a hypothetical deduction, maybe in a reductio ad absurdum: \textit{We have said he is not here; but/for if we (had) assumed otherwise...}

The decision tree model supports a more detailed version of this story. Suppose I sit at R and try to figure out where I am. I say \textit{if I turned left at root I am at L.} The first tense is a straightforward indicative past referring to the root: if as a matter of fact I did turn left. The present tense refers to the actual present. Now compare \textit{If I had turned left at root I would be at L}. Here the double past \textit{had turned} goes back to a choice point before the turn to replace the event that actually occurred there with another one. The past future of the main clause starts out there, turns left as the new condition requires, \textit{goes forward} in time and ends up at L. Thus a \textit{past future} movement in branching time does get us to a \textit{hypothetical present} possibly simultaneous with the actual one. This explanation also covers the use of simple past \textit{turned} to indicate nonpast distinction in counterfactual conditions. i.e. the fact that the sentence \textit{if I turned left now I would end up at L} would be said at root. In other words, in a branching future model, the main clause counterfactual conditional can in this representative case be literally interpreted as a past conditional. This situation thus provides a case of \textit{modal competition}, or neutralisation between past and counterfactual.

Another universal of counterfactuals can be adduced here. It is the preference for imperfective aspect in a nonpast antecedent of a counterfactual conditional. Imperfective can express a plan set aside: \textit{I was turning(about) to turn left before I changed my mind.} This makes the past imperfective in effect another past future form: \textit{if I was to turn left (which I am not) I would end up at L.}\footnote{For the use of imperfect in Romance languages Thieroff (1994:22). Cf. Kühner (1966): \textit{... der Indikativ der historischen Zeitformen mit an (ken) [dient] zur Bezeichnung einer Handlung, die unter gewissen (entweder ausdrücklich ausgesprochenen oder wenigstens angedeuteten) Bedingungen geschehen konnte, aber nicht verwirklicht wurde, weil die Bedingungen nicht erfüllt wurden. Meist steht der Aorist, als das Tempus der abgeschlossenen Handlung, mit Beziehung auf die Vergangenheit, das Imperfekt dagegen, als das Tempus der sich entwickelnden Handlung, mit Beziehung auf die Gegenwart. Die letztere Erscheinung ist ebenso zu erklären wie die entsprechende Form der Wunschsätze ... (§393,6). ... die Bedingung erstreckt sich zwar auf die Gegenwart; aber ihre Erfüllbarkeit gehört der Vergangenheit an, da bereits über die Nichtverwirklichung entschieden ist; unter dem Gefühl dieses Gegensatzes versetzte sich der Redende in die Zeit, wo die Erfüllung noch möglich war. (§574, Anm.2).}

A related feature is the tendency for hypothetical past to double (Jespersen 1949:§9.7.9, Bybee et al. 1994: 234, Lindsedt 1985:251, Comrie 1986:94). Instead of saying \textit{I am going to turn right, for if I turned left I would end up at L}, one may say \textit{if I had turned left, I would have ended up at L}, although the turn is still ahead.\footnote{There is a substandard further doubling in \textit{If I hadn’t have lost that watch bracelet I’d feel like the bloody German emperor} (Jespersen 1954:322, Hirtle 1975:127).} Although the event is ahead, the decision is past, so the double past is actually short for \textit{if I had chosen to turn left}.\footnote{Compare the use of the perfect of foregone future events \textit{The Czechs have (in effect) already won the match.}}

Summing up, we must recognise \textit{past future} \textit{t><u} as a modal/temporal relationship of its own. In linear time, it is not a particularly interesting relationship, for it trivially holds between any two times. In branching time, it allows a separation of events in the space of possibilities in addition to (or instead of) time. This might be the generalisation between past and irrealis which Lyons (1977) was looking for.

**Evolutionary typology of reflexives**

New reflexives come in through abstract nouns and personal pronoun or combinations of these. Genusiene (1987) sums up the evolutionary progress of reflexives in four stages. This is the old story of layering again. To make the story shorter, I slice it up into three stages:

(i) Old grammaticalised reflexive displays a wide range of reflexive functions and a new compositional one binds explicit argument places. (Russian and Baltic languages)

(ii) Old and new reflexives cover about the same range. (classical Latin, old Norse)

(iii) The new reflexive is productive and the old reflexive is lexicalised or restricted to a small number of uses (vulgar Latin)

The picture can be detailed using a classification of reflexive types. That in turn reflects back on the classification used.

The first role ousted by a compositional reflexive object type is straightforward object reflexive. Genusiene (1987: 245) points out that this is precisely what is \textit{not} expressed by reflexive inflexion in classical languages. Klaiman’s (1991) theory of the middle voice makes much out of the fact. Its flip side is the observation that English \textit{‘new’}, compositional \textit{‘active’} reflexive avoids mediopassive readings.

It appears from Genusiene’s Table 9 (1987:244) that her two type 2 reflexives (partitive object and dispositional) reflectives pattern quite differently across languages. Partitive object reflexive is common and available for young
reflexives, while the dispositional sense patterns with old reflexives. In my analysis their event types above look quite different. The partitive type does not go inside verb diathesis, which the dispositional one does.

Genusiene’s cross-linguistic survey gives the following gut feeling about the relatedness of reflexive types. The basic senses are active reflexives where subject is identified with object. They should be among the first ones to come in, and hence first ones to be masked by a new incoming reflexive.

<table>
<thead>
<tr>
<th>x cause y cover x with y</th>
<th>Ona nakrylas’ odejalom ‘She covered herself with a blanket’</th>
</tr>
</thead>
<tbody>
<tr>
<td>x squint y of x</td>
<td>Ona prishchurilas’ ‘She squinted (her eyes)’</td>
</tr>
<tr>
<td>x throw x forward</td>
<td>On brosilsja vpered ‘He threw himself forward’</td>
</tr>
<tr>
<td>x cause x sit down</td>
<td>It visi su(s)isedo prie stalo. ‘Everyone sat down at the table’</td>
</tr>
</tbody>
</table>

The last type where reflexive seems optional could be a case of unmarked causative (conversion). Oblique reflexive is in a class on its own. There is nothing complicated about its semantics, as long as a language can mark obliques reflexive. Many can not. Grammaticalised oblique reflexive (middle voice) is not that common (Genusiene 1987: 335).

| x cause y become tame to x | It Jis pri(s)jaukino lapem ‘He (has) tamed himself a fox’. |

Passive reflexive is dual to reflexive causation: an active thing makes things happen to itself, a passive one lets things happen to itself. The passive reflexive type is found in all languages of the sample. These types are intransitive in English.

| x let 1 break x           | Steklo razbilos’ ‘The glass broke’                         |
| x let 1 open x            | Dver’ otkryvajetsja legko ‘The door opens easily’          |

Agentive passive reflexive is a grammaticalisation of a reflexive converse or factitive reflexive. (Genusiene 1987:261-269). These are result passives in English.

| y let|cause x hear y to x | Mne slyshitsja muzyka ‘I can hear music’                     |
| x let|cause 1 reflect x in y | Nebo otrazhajetsja v ozere ‘The sky is reflected in the lake’ |
| x let y shave x by y      | On pobrilsja u parikmaxera ‘He had himself shaved by a barber’ |
| x let 1 build x by y      | Dom stroitsja sosedom ‘The house is (being) built by the neighbor’ |

Impersonal reflexives are not among first comers either. These constructions go with a ‘passive’ language where ‘they’ do things to one or things just happen. Very Finnish, very un-American.

| I cause 1 dance           | me Vo salata se tancuva ‘There is dancing in the hall’      |
| I cause 1 shave x         | pl Mojego kolegem goli siem v domu ‘They shave my colleague at home.’ |
| I let y obey x by y        | It Legibus a civibus paretur ‘Laws are obeyed by citizens’   |

Antipassive readings take an old reflexive too, but form an entirely different kettle of fish, diametrically opposite to the previous lot, since here it is the object that is played down. These too are intransitive in English.

| x cause x throw 1 with y   | On brosajetsja kamnjam ‘He is flinging round with stones’   |
| x cause x dig 1 in y       | On rojetsja v Jame ‘He is digging in the hole’              |
| x cause x bite 1           | Sobaka kusajetsja ‘The dog bites’                          |

Reciprocal is a reading for well matured reflexives. Scandinavian suffixal reflexive is reciprocal, phrasal reflexive not.

| (x and y) kiss (y and x)   | Brat i sestra pocelovalis’ ‘The brother and sister kissed (each other)’ |
Genusiene (1987:§4.4) classifies reflexives into subjective, objective and transitive types. Subjective equals my active reflexives, objective equals my passive reflexives and transitive means oblique reflexives. Of the eight selections from this set, three are attested. The largest type of languages has all three types of reflexives. The second largest class excludes oblique reflexives. The third type, attested by Nivkh alone, only allows active reflexives. Genusiene concludes that evolution of reflexives follows the order subjective < objective. The transitive type does not seem to be on the same developmental cline (Genusiene 1987:343).

Genusiene (1987:305) concludes that evolution of passive reflexives follows the order reflexive < decausative < passive. She does not exclude a reverse evolution iterative < inchoative < passive | reflexive. In my view, a possible process would be iterative < antipassive.

Among the subtypes, the order of typological markedness, and likely order of evolution, is given in the order of items in the tables.

Why should it stack just this way? I bet a complexity count of the event types falling into the range of the reflexive can be established which predicts the developmental paths here. What complicates the metric is that development does not happen in a void, there is competition between forms.

This shows in typological correlations. Baltic languages and English do not use reflexive for passive constructions, but passive participles. Russian and Baltic languages do not use reflexive for impersonal constructions, but impersonal verbs. English does not use reflexive for medial or passive reflexive constructions, but intransitive verbs. Russian has a reflexive passive, Lithuanian a result passive (Genusiene 1987:270,346).

But look at grammaticalisation of reflexive from a more abstract perspective. What happens when reflexive grammaticalises to middle is (as Klaiman has stressed) that it turns from a change in argument structure (argument place reduction) into a change in functional structure, i.e. into a modality or mood. This is the dual flip from relation algebra to function algebra. (Recall algebraic semantics of modality). What used to be an argument becomes a functor. Here is the mechanism of the abstraction laid bare.

| x cause x p | ¬x let x p | 1 let x p | x may p |
| ¬x cause x p | x let x p | 1 cause x p | x must p |

An active reflexive turns into a weak permission modal and a passive reflexive turns into a strong necessity modal by flipping between reflexive binding of object and existential binding of the subject. What happens in the abstraction is that reflexive now binds implicit places in an event type which no longer appear as argument place reduction. As it is abstracted, i.e. constants in the argument structure are replaced by variables to be instantiated in context, the event type also becomes more contextual or indexical. We cannot tell any longer exactly what it is that licenses the reflexive without looking at context.

This makes the logic of grammaticalisation of the reflexive another instance of the general logic of grammaticalisation: increased abstraction, increased indexicality.

**Morphological typology**

This section looks at morphological typology from the perspective of logic. Linguistics makes do with vague or prototypical definitions which cover central cases but leak at the edges. The difficulty may be inherent in the subject matter of linguistics. The derivation-inflection distinction is one.

**Inflection**

How to distinguish derivation and inflection? This is one of the eternity questions of linguistics. I do not presume to settle it, but try to relate it to the logic of grammaticalisation. There are several partial answers in the literature, which I review with comments.

1. Inflections are productive.

What this means in mathematical terms is that an inflection is a total function on some category. Any function is total on its domain, so the worth of the criterion depends on the size of the category. The traditional domain of inflection is part of speech, where parts of speech are thought of as atoms. I prefer to think of categories as a Boolean algebra (compare section on grammar). A function which is total on a larger category is more of an inflection.

2. Inflections do not change category.
Category (part of speech) indexes grammatical distribution. This is graded when categories become Boolean. This is not a sufficient condition (derivation need not change category). It is not necessary either if participles turn verbs into adjectives and inflectional cases turn nouns into adverbials.

A better way of putting this criterion is that inflection relates to stem as modifier to head, while derivational endings are heads of their constructions. The point of a head-dependent relation is that the head stands for the phrase (determines its distribution). Headedness too becomes relative if categories are Boolean.

3. Inflections change function.

By another commonly proposed criterion inflections change grammatical function, or the position of a word in a sentence. We may distinguish between downward and upward conditions on distribution here. For instance, a participle inherits the form and distribution of its dependents from the verb but assumes the upward distribution of an adjective.

4. Inflections are unique per word.

There should not be several inflections of the same sort on one word. This does not rule double or distributed marking, but does exclude iteration.

5. Inflections are obligatory.

The dual half of uniqueness is existence. This too is debatable. Many inflections remain unmarked, like singular number, present tense, simple aspect, or indicative mood. But does you are here (written on a map) mark number? There is not much point in saying so. Here obligatoriness amounts to a closed world assumption: unmarked entails the complement of marked, if any.

6. Inflections form paradigms.

Together, existence and uniqueness imply the idea that inflections fill slots rather than stack as operators. Inflections are functions which take one of a small number of alternative values. The forms generated for these different values form a paradigm of mutually exclusive and jointly exhaustive forms, a partition of the semantic space covered by the attribute. The paradigm is what fixes the value of the unmarked form, as the relative complement of the sum of the marked values with the attribute. (For instance, unmarked present means different in English and Finnish.)

7. Inflections are features.

A stronger condition is that an inflection restricts the denotation of the word. An inflection is an attribute of a word in the sense that it takes meets with the denotation of the word. This entails idempotence.

8. Inflections are indexical.

Well, some of them are, like person and tense. Others are not, like number and gender. This property may be sufficient, but not necessary for an inflection.

9. Inflections are final on a word.

What is meant is that inflections are outermost on a word. This idea has many aspects. One is that all inflection follows all derivation, an inflected word cannot enter derivation. This is a definite constraint on the derivation-inflection distinction, but does not say where one ends and the other begins.

My idea here is this. Grammaticalisation is a process of abstraction which maps a grammatical category toward the initial object or universal element of a category in a category theoretic sense. The grammatical properties of inflections reflect logical properties of initial objects.

Take examples. The plural inflection (like Finnish t in puu-t ‘trees’) differs from a productive collective derivation (puu-sto ‘collection of trees’) and even more from a nonproductive one pu-i-sto ‘park’ by the morphisms it allows. Puut stay the same as long as the trees are the same, however they are grouped, puusto denotes the stand of trees of a region, give or take a few, while puisto hardly needs trees at all.

Given structure, iteration makes a difference Puisto-sto or puisto-t are possible words. But there is no plural of a plural, in Finnish at least. Nor a derived singular of a plural either. If number is idempotent, repeating or undoing the mark makes no difference. This is an argument for a Boolean treatment of number, where singular stands for an atom and plural for any element of a Boolean algebra. Then number takes meets, and is idempotent: \( pl = sg \) \( pl = pl \) \( pl = pl \) \( sg \).

(This won’t go through in set theory where plural shifts type.)

So perhaps uniqueness of an inflection indicates the idempotence (or nilpotence) of the operation expressed by it. Applying it twice is either vacuous or inconsistent (empty).

The conjecture seems to work in many cases. There is no sense in repeating comparatives, for instance, for choice functions are idempotent. Identical tenses are idempotent. Opposite tenses are not, and they do occur as inflections in some languages. Indexical reference is unique.

Let me survey the criteria from this point of view. Inflections are productive because they act on the initial object of a category. For forming plural, it is enough for the root to have atomic denotation, anything else goes. An inflection does and does not change category, depending on which category one looks at. There is always some category which it changes (unless it is an identity) and one which it does not (the least common category of the input and the output). The
less that changes, the more of an inflection. Plural is more of an inflection than participle, a grammatical case more than a semantic one, being initial in a bigger category.

What about finality? There are well-known tendencies concerning the order of inflections on words (Bybee 1985). If logic has a say here, order should be consistent with scope. That is not much to say, for scope is easily flipped. There must be a notion of normal form. Take number and case for instance: fi talo-i-ssa inverts fr dans les maisons (plural is marked on the article in speech). What if it went the other way pl in house? Could it mean the same? To be fair, we must assume that house is unmarked for number here, so it can denote any number of houses. in house then denotes whatever is in house. What does plural do? Not what we want: it pluralises whatever is in house, not the houses.

Degree of relatedness, relevance, or natural serialisation really comes down to ordering morphemes so they say what is meant, given the morphemes mean what we take them to mean. For instance, there is a more involved typology of the plural which allows it to appear outside and pluralise into the construction, but relative to the given primitives, it is more involved. Often the order is not fixed. Finnish allows saying rann-empa-na shore cmp at ‘closer to the shore’ where the comparative applies to the noun and not the adverb as in English. Given shore is a vague notion, it comes to the same: to be closer to the (absolute) shoreline is to be at more of a shore.

Derivation
Derivation is just a tight way of packing event types and event type combinators. The same types and dualities appear here as in free forms (Bybee 1985:38). Again I suspect that the field of options is way simpler underneath than it appears on the surface.

There is a duality between singular closed passive inchoative semelfactive and momentaneous against plural open iterative, causative and reflexive aspect and diathesis markings in many languages (witness Indo-European intransitive-momentaneous -n vs. causative-iterative -i- Krahe 1969:77).

Starting from vihreä ‘green’ Finnish has apparent causative vihertää (vih-TA) ‘be, become green’, causative-reflexive vihertyä (vih-T-U) ‘become green’, T causative and U passive-reflexive, iterative viheriöitä (vih-I-A-I) ‘be green’, T plural or iterative. The Finnish causative and passive T has been suggested to derive from the same root as the verb tek-‘do’. From puna ‘red’ there is causative puna-T-a ‘make red’, punhteua (pune-K-T-U) ‘redder’ where K could be an oldative or goal case, and punoittaa (puna-I-T-T) ‘rubesce’. From vaalea ‘bleak’ there is vaaleita (vaale-N-) and vaalentua (vaale-N-T-U)- possibly related to the comparative vaaleampi (vaalea-N-PA), where PA is a participle. Norwegian grønne-s ‘be, turn green’ exemplifies reflexivisation.

What we find is the familiar list of suspects for initial objects of the categories of aspect and diathesis in the guise of derivational morphemes: pl, *9, pf, once, cause, become, refl, exemplifying the very same analogies and morphisms. Reflexive, causative, passive and iterative derivatives easily swap forms or meanings even in one and the same language. This reflects the tight logical combinatorics of these operators. For instance in Turkish languages passive l and reflexive n have similar functions. The reflexive n has been assumed to come from an iterative (Genusiene 1987:304).

Why aspect and diathesis derivation? Why not tense and mood? Tense and mood tend to be inflectional, not derivational. This is partly a matter of definition, but not wholly. The derivation-inflection cline is a difference in grammaticalisation, contextuality or indexicality.

Can we construe tense and mood as grammaticalisations of aspect and diathesis, respectively? Can we consider TA and MD as sides of two orthogonal dimensions, say events in time against objects in space? That is a thought. But there is also a straight line from diathesis to aspect. There is another fourfield here:

Figure 27
If diathesis equals the event calculus, then it obviously feeds everything else. It feeds mood through game modalities. It feeds aspect through the topology of events. Mood and aspect feed tense through temporal modality and the order structure of time. The type-token distinction runs on the falling diagonal, taking a maximum northeast at token-reflexive finite forms and a minimum southwest at the initial objects of the category of diathesis, the "megista gene." How does this arrangement relate to the natural serialisation of TMAD operators? It correctly predicts that tense is outermost, diathesis innermost, and mood and aspect fall between. It does not decide the order of mood and aspect. Mood and aspect are in something of a competition: typically, there are more aspects in the indicative. The Creole prototype has mood over aspect. Finnish has perfect over modal verbs. Both scopings make sense, though partly different sense: an epistemic modal is logically outside aspect, a dynamic one inside. The rule seems to be that the more grammaticalised operator comes outermost. Finnish perfect is "old" (tense like), while Finnish modal verbs are "young" (main verb like). English perfect is "young" (aspect like) and its modals are "old" (auxiliary like). So maybe everything is as it ought to be.

**Logical typology**

Following van Benthem (1985,1986), we can try to classify temporal expressions in terms of increasing commitment as to the structure of time by looking at their invariants, or meaning preserving mappings. At the lowest scale, we have temporal quantifiers _always, never, sometimes_ which are invariant under all automorphisms. If something always or never happens, that remains true for any permutations of past, present, and future. All (not only) first order definable tenses and aspects are _order-preserving_ (distinguish _before_ and _after_). _Continuity_ allows those aspects that are commonly grammaticalised. Continuity does away with aspects and discontinuous changes of granularity. Invariance under linear transformations (changes of scale, i.e. origin and unit of measurement) preserves comparisons of distances (_long_ and _short_) but not measurement of distances which fix the unit (_second, hour, minute_) nor dates with fixed origin (_now, today, June 7, 1997_).

Logical results like this go a long way toward explaining relative complexity and markedness in natural language tense and aspect. As van Benthem (1986) points out, they distinguish what is _valid a priori_ from what is not, thus enabling one to focus more sharply on empirical questions. Logical typology defines logically possible tense and aspect systems for languages. At the same time, existing languages can be compared empirically how they express certain specific types of temporal distributions.

A consequence of the shared Boolean structure in the different domains of natural language is that their logic is the same (Keenan/Faltz 1985). The logics of weak operators double negation _¬¬_, positiveness _?_ or _⊃_, join _∪_, existance _∀_, iteration _eᵩ_, and possibility _may_ are the same. Dually, the same holds of strong operators double negation _¬¬_, unity _1_ or _≡_, meet _∩_, conjunction _∧_, universality _Af_, eternity _eᵩ_, and necessity _must_. The list is not complete, morphisms extend to other modalities, tenses, aspects and diathesis operators. The shared logic is the modal logic _S5_, which is the classical permutation invariant modal logic (van Benthem 1986).

In the categorical domain of Boolean algebra, (binary) truth definitions and quantifiers are logical properties of (pairs of) event types. In van Benthem’s characterisation, a property is _logical_ just when it is _quantitative_: preserved under arbitrary one-one mappings, alias _permutation or automorphism invariant_. A logical property does not care about of the identity or quality of objects, just their quantity or number. This constraint nicely picks out the classical _megista gene_ of natural language semantics as the initial or final objects of their respective categories. (van Benthem 1986).

The category theoretic idea of characterising natural language concept types by the morphisms which preserve them can be generalised. The generalisation is called principle of Quality in van Benthem (1986). For instance, Boolean algebra is preserved under Boolean morphisms. Aspect is preserved under continuous mappings. Comparison is invariant under monotone (order-preserving) morphisms. This result applies to various semantic notions which depend on comparison, such as dyadic modals, counterfactuals and causation (van Benthem 1986:83,87). Tenses respect temporal order (van Benthem 1986:102). Measures are preserved under linear (affine) mappings.

**Hierarchies and invariants**

A possible TMAD system is a selection of distinctions from those expressible in the formalism(s) to be grammaticalised in (a) language(s). To compare TMAD systems in terms of expressive power, one would need to find some language independent and cross-linguistically valid way to enumerate event types. Logically, though the calculus does not impose any unique grid or hierarchy of distinctions, some classifications are simpler to express in it than others. A limitation of the deductive approach is that languages are adaptations to an environment. What is mathematically simple may not be salient in life, there can be anthropomorphic discontinuities.
At least the enumeration must be many dimensional and cross classifying, which entails that the theoretical number of distinguishable event types is going to be large. At the same time, any given languages makes rather few tense and aspect distinctions, and the total number of different distinctions made is sure to be much less than the average system size times the number of languages. Although the total number of non-identical systems may be rather large, most of them probably only differ in the margins, so that there is a small number of very common prototype systems.

These facts should be reflected in the enumeration of event types. It should proceed by way of stepwise refinement, starting from the most basic distinctions that most languages make. (Rather like a deductive version of the inductive voting procedure used by Dahl to arrive at his prototypes.) It would be good if the basic categories would arise from basic distinctions between categories, so that establishing a category would at once establish its paradigmatic opposites.

An important insight to derive from logical typology, related to the idea of a calculus, is that the name of the game is not to look for one finest matrix of event types to cover all TMAD distinctions any human language makes at once (even though one, as an empirical fact, must exist, given that there is a finite number of natural languages). Rather, the point is that choices of different selections of distinctions generate different typologies, and any typology can be further refined by including further distinctions. For any type of phenomenon, it suffices to find that level of complexity on which the typological issue can be described.

For instance: there are dense interconnections between different final (goal, passive, past, resultative, perfective) on the one hand and initial or medial ones (source, active, agentive, present, imperfective, progressive) on the other hand. Such generic clusters form one level of abstraction for typological comparison and analysis which does not yet compromise the detailed analysis of such markings. (cf. the typology of I and D languages of Ritter/Rosen 2000).

Consider the set of cross-linguistically most common aspects (grammaticalised event types). A coarsest taxonomy divides event types into open and closed ones. Closed event types divide further into half-closed events (changes) and cycles. Open events divide into further into states and iterations of closed event types. Cycles of iterations and iterations of these again define more complex event types. Each degree of complexity of event types, as regular expressions, generates a taxonomy of event types up to that complexity.

This implies that questions of completeness of a TMAD system are also relative to the the typology of events (model theory) assumed. It may be a tautology that any human language TMAD system is expressively complete relative to its own intended models, i.e. it can denote all event types on its own level of resolution. The question that interests a logical typologist (or a translator) is whether different calculi are translatable relative to some given set of models.

**Language does not count**

A general observation is that (natural) language does not count – rather, its grammar does not. (Chomsky 1965). Research on formal languages has come up with interesting ways to make this observation more precise. There is an interdependence between the following notions in finite state automata theory:

- Expressible in Booleans and concatenation
- Expressible in first order logic

The (extended) star height of a regular language is the smallest number of stars needed in an equivalent (extended) regular expression. Star height reflects the complexity of the finite automaton producing the language. The existence of regular languages of extended star height over one is open (Pin 1997).


There is an analogy between alternating sequences of operators and noncounting languages here. Idempotence $OOp = Op$ (“all iterations reduce to one”) characterises aperiodic monoids, while involution $OOp = p$ (“even iterations reduce to none”) requires a counter machine.

It is not quite true to say that a noncounting event type does not count. It does count, but modulo $2: 0,1,0,1$, now you see it, now you don’t. This is counting with truth values, in Boolean numbers. Compare proofs of equivalence of noncounting languages with combinations of binary automata (Meyer 1969 and McNaughton/Papert 1971).

**Typology and counting**

If natural language does count it does not count far, in grammar anyway. Typologically interesting phenomena can be exemplified in models of small size. The smallest free Boolean algebras $2, 4, 16$ already do a lot. The two-element algebra defines complement, the other Booleans reduce here. The four element algebra of Aristotle’s square of opposites makes a second distinction between type and token, or one and many. In fact, traditional labels for the two axes of Aristotle’s square of opposites are Quality for the horizontal axis between contraries and subcontraries, and Quantity for the vertical axis between subalterns. The contrast between all and none was qualitative, that between all and some quantitative.
In 2. tertium non datur. In Aristotle’s square or the Klein four group there is a tertium. It is the tertium comparisonis, the contingent middle term some but not all between all or none. There is a dual triple between the quantifiers all or none (some iff all), one and one not, which is the quantifier analogue of the duality of Boolean equivalence and sum. Similar triples are formed by other Boolean combinations of quantifiers (e.g. some and all).

Three is the smallest size in which the topological notion of between and its dual next as well as the notion of transitivity can be defined. Comparison makes a three-way distinction between positive (no comparison), comparative (binary comparison) and superlative (comparison of three or more). Natural language tenses and aspects belong to the three-variable fragment of first order logic. Three turned out to be a limit of expressive power for relation algebra as well. van Benthem (1986) points out that natural language types in general do not seem to go past third order, or the power of plural quantifiers.

There are many counting theorems on natural language TMAD systems which involve larger numbers than four. Many such theorems can be traced back to the Boolean series of powers and two and their sums or differences. Typically, the “raw” number of distinctions is some power of two, which after removing symmetries, duplicates or degenerate cases reduces to more mysterious numerology. (Westerståhl 1989:110ff)

For instance the number of distinct binary Boolean connectives is 10, which is 16 minus the 2 Boolean constants and the 4 unary ones. The number of distinct Priorian tenses by Hamblin’s theorem is 14, which is (16-2)/2, leaving out simple aspect and disregarding negation. There are 7 interestingly different ways of order two intervals, related the 16 ways to order pairs of points on a line. The number 9 of Reichenbach’s tenses is the number of of ordering three points on a line. There are three ways to order two points, one less than the number 4 of their partial orders.

Counting theorems are of definite but limited interest from a typological point of view. Counting provides exact but featureless information. The same number can be obtained in many ways, there are far fewer numbers than functions. In empirical typology it is usually hard to decide what to count.

But counting theorems provide ballpark estimates. If a language has clearly more or clearly less than n forms in its paradigm, where n is a relevant count of a known category, then that paradigm is not an obvious instance of that category.

Logical typology of quantifiers

The observations in the section on truth and negation indicate why some is the least marked quantifier, and none is its denial. Some may be left out entirely, so its denial none may be expressed by negation alone. All is positive but marked and some not is doubly marked.

By duality, the unmarked connective is and. Asyndetic connection is read as conjunction. This follows from the duality of tokens and types. Setting the type of tokens to X, the type of quantifiers is covariant to it, being doubly dual 2e−2e−X. The type of connectives 2e−X is dual to X and contravariant.

Westerståhl (1989) defines quantifiers as isomorphism invariant second order relations of relations. Quantifiers like nobody came are monadic unary, quantifiers like some A are B are monadic binary, or binary relations between predicates.

Binary quantifiers like some A are B or many can be viewed as quantitative Boolean relations c→aQb between a and b depending on context c and classified by denotational constraints beyond that of Quantity. Context independence and conservativity together say that aQb equals 1Qb∩a2, a restricted unary quantifier living on a. (Westerståhl 1989:64).

Many is context sensitive. Only is nonconservative. One is nonmonotone but continuous. Most is right continuous. The four combinations of left/right increasing/decreasing characterise the quantifiers of Aristotle’s square of opposition (van

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268 Come to think of it, any number at all fits this description, but not all “interestingly”.

269 Number is covariant, singular and plural are not dually related. Constituent conjunction he and she is interchangeable with plural they.
Bentham 1986, Westerståhl 1989:71). They are also characterised by their relation properties (Westerståhl 1989:88ff). Not surprisingly, preorder entails left decreasing and right increasing. The converse does not hold, e.g. *almost all.*

<table>
<thead>
<tr>
<th>quantifier</th>
<th>properties</th>
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<tbody>
<tr>
<td>all</td>
<td>partial order</td>
</tr>
<tr>
<td>some</td>
<td>symmetric, almost reflexive</td>
</tr>
<tr>
<td>no</td>
<td>irreflexive, symmetric</td>
</tr>
<tr>
<td>not all</td>
<td>irreflexive, cotransitive, linear</td>
</tr>
</tbody>
</table>

A proposed language universal says there are no asymmetric determiners. A relation \( r \) is asymmetric if \( r \cap -r = \emptyset \) so \( r \subseteq \emptyset \) and \( -r \subseteq \emptyset \). Boolean algebra \( 16 \) or the domain of binary relations in \( 2 \) has two asymmetric ones. The domain of binary relations in \( 4 \) defines \( 2^{4*4} = 65536 \) relations. The only ones which have a Boolean morphism to \( a \rightarrow b \) in \( 2 \) are \( a \rightarrow b = 1 \) and \( a \rightarrow b > \emptyset \). The former reduces to the unary quantifier \( a = 1 \) and the latter is not asymmetric in \( 4 \). It follows that there are no asymmetric Boolean relations past \( 2 \), for Boolean morphisms are positive increasing.

Quantifiers can equally well be regrouped as determiners (**many** \( a \) \( b \)), or Boolean functions \( pa = a \cap 1 \), and characterised by the corresponding function properties. One may then wonder why natural languages do not have one word determiners of the incontinent type *some not / not all* when the other three corners *some, all, none* are attested. Not all languages pack *none* in one word either. What many do have for it are negative polarity quantifiers like *any* (Ladusaw 1980, Zwarts 1986). Westerståhl (1989) produces a combination of conditions which single out *not all* type, but it is not a very transparent one.

Here is one way to think about it. If we ask who *came?* there is a definite answer for the tree existing quantifiers. For *none came* \( \emptyset \cap \text{come} \) it is *nobody* \( \emptyset \). Nobody is a definite answer, it is one thing, though it is empty. For *some came* \( 1 \cap \text{come} \) it is those who did, or *come*. For all *came* \( 1 \cap \text{pt come} \), it is everybody, or \( 1 \). There is no answer left to frame *not all came*, for it can’t well be those who did not *~come*, because they did not. That does not answer the question.

One difference, then, is that the three existing quantifiers have a Boolean denotation, *not all* does not. My condition can be considered a slight generalisation of *definiteness* (Westerståhl 1989:81). But there are likely to be many reasons for any good thing (ibid. 114). Another, probably deeper reason has to do with truth definitions (see section on truth and negation).

**Many, more and most**

*Many* is a comparative quantifier with an absolute *more than one*, proportional at least *half* or frequency threshold like *at least every other* (Westerståhl 1989). This last option makes sense of open event types like *most days are weekdays.* (van Bentham 1986, 1991). In a continuous noncount space, a metric to compare by is implied (van Bentham 1991).

*Most* is the superlative of *many, more* is the comparative. *Most* means a majority, i.e. *more than not, or more than half,* in number or frequency. *More* defines *most,* the converse holds in finite models The difference is that *more* can define infinity (a set has no more members than its subset). (Westerståhl 1989:31,49).

The Aristotelean quantifiers can be defined by simple two-state finite automata, so they are regular. *More* is not regular but context free, as it involves (in)equality of two arbitrary large quantities. (Comparative relations in general are context free.)

The complement of *many* is *few* or *almost no,* whose meanings vary in correlation with those of *many* from *not more than one or not more than half to at most every other.* The dual of *many* is *almost all,* or *not many.*

In this scheme, *some* means *more than none,* its *all* is or *not more than none not.* The dual of *most* is *not more than not not,* or at least *half* (van Bentham 1986:§2).

We get the four groups:

<table>
<thead>
<tr>
<th>definition</th>
<th>characteristic</th>
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<tr>
<td>most</td>
<td><em>more than not =</em></td>
</tr>
<tr>
<td></td>
<td><em>more than half =</em></td>
</tr>
<tr>
<td>not most</td>
<td><em>at most half =</em></td>
</tr>
<tr>
<td></td>
<td><em>at least half not =</em></td>
</tr>
<tr>
<td></td>
<td><em>not more than half =</em></td>
</tr>
<tr>
<td>at least as many as</td>
<td><em>at least half =</em></td>
</tr>
<tr>
<td>not</td>
<td><em>many =</em></td>
</tr>
<tr>
<td>most not</td>
<td><em>more than half not =</em></td>
</tr>
<tr>
<td></td>
<td><em>less than half =</em></td>
</tr>
</tbody>
</table>

**Table 84**

<table>
<thead>
<tr>
<th>definition</th>
<th>characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>almost all</td>
<td><em>at most one not =</em></td>
</tr>
<tr>
<td></td>
<td><em>all but at most one =</em></td>
</tr>
<tr>
<td></td>
<td><em>all but less than two =</em></td>
</tr>
<tr>
<td>not almost all</td>
<td><em>many not =</em></td>
</tr>
<tr>
<td></td>
<td><em>more than one not =</em></td>
</tr>
<tr>
<td></td>
<td><em>at least two not =</em></td>
</tr>
</tbody>
</table>
**many** = more than one = at least two

**few** = not many = almost none = at most one

<table>
<thead>
<tr>
<th>Table 85</th>
</tr>
</thead>
<tbody>
<tr>
<td>These represent extremes for the interpretation of many in that many cannot be less than two if it is to be different from some or one, and it cannot be more than at least half if it is to be different from most or almost all. The logics of most and many fall between those of all and and some, all entails most entails many entails some in a domain of at least two. The entailments are proper in a domain of three. In a domain of sufficient size, some and many allow Q do and Q don’t which all and most exclude. Conversely, some and many obey excluded middle Q do or Q don’t, while all and most allow a gap (the latter only when votes go even). The differences appear in distribution. Some distributes over join and all over meet. Many and most do neither.</td>
</tr>
</tbody>
</table>

\[
\neg (\text{most } p \cap \text{most } \neg p) = 1 \quad \quad (\text{many } p \cup \text{many } \neg p) = 1
\]

\[
\text{many } (p \cup q) \rightarrow (\text{many } p \cup \text{many } q) < 1 \quad \quad (\text{most } p \cap \text{most } q) \rightarrow (\text{most } p \cap q) < 1
\]

The converses of the last line above do hold. Iteration of most dwindles fast. A majority of a majority is more than a quarter, but no longer a majority. The converse holds of course.

\[
\text{most } p \rightarrow \text{most most } p = 1 \quad \quad \text{most most } p \rightarrow \text{most } p < 1
\]

In terms of binary most, if most swans are white and most white swans are female, more than a quarter of the swans are female white ones. This may be many, but not most unless there are less than four swans.

The logic of many, more and most is the logic of comparison: order relations, preference and choice. Comparison is built into Boolean partial order of inclusion, counting into atoms of an atomic Boolean algebra, measurement into sigma algebras (Halmos 1974).

**Proportional quantifiers**

Proportional quantifiers on a finite domain may be calculated in rationals with the cardinality mapping of a finite Boolean algebra to the natural numbers. Natural numbers form a Boolean algebra with 0 as zero, N as unit, and min and max as meet and join, respectively.

Cardinality maps Boolean ∅ to 0, atoms to 1 and Boolean sums of relative atoms to +. This mapping is a homomorphism so that \( a = b \) entails \( |a| = |b| \) but not conversely. In addition,

\[
0 \leq \max(|a|,|b|) \leq |a\sqcup b| = |a|+|a\cap b|+|b| \leq |1|,
\]
\[
0 \leq |a\cap b| \leq \min(|a|,|b|) \leq |1|,
\]
\[
0 \leq |a\sqcup b| \leq |a|+|b| \leq 2|1|.
\]

Here identity \( |a+b| = |a|+|b| \) holds iff \( a\cap b = \emptyset \). Further \( |1|a = |1|\neg a \) and in general, \( |a\sqcap b| = |a\neg b| \) iff \( b \subseteq a \).

More men left than girls came means \( |\text{men}\cap\text{leave}| > |\text{girls}\cap\text{come}| \). Most men left means more men left than not, \( |\text{men}\cap\text{leave}| > |\text{men}\\setminus\text{leave}| \).

By Boolean logic,

\[
\text{men} = \text{men}\cap 1 = \text{men}\cap(\text{leave}+\text{leave}) = (\text{men}\cap\text{leave})+(\text{men}\\setminus\text{leave})
\]

which entails by the above properties of finite cardinalities that

\[
|\text{men}| = |\text{men}\cap\text{leave}|+|\text{men}\\setminus\text{leave}|
\]

From the last two cardinality equations it follows that most is a proportional quantifier.

\[
|\text{men}\cap\text{leave}|/|\text{men}| > \frac{1}{2}
\]

or more than half of the men left.

Zadeh (1977?) applies proportional thinking to comparative relations in general. If good is defined better than most, and very good is defined as good among the good, then very good amounts to the second power of good or the square of the proportional choice function. Then very good amounts to being in the best fourth.

Zadeh (2002) has pointed out inference schemes for proportional quantifiers:
Q1 A B and Q2 A∩C C entail Q1*Q2 A B∩C.

For instance, if more than half A are B and more than half A and B are C, then more than a quarter A are C. This can be easily proved by Boolean algebra and arithmetic when the cardinalities are finite. A dual principle is

Q1 A B and Q2 A C contradict ¬(Q1+Q2) ¬ A ¬(B∩C)

For instance, if most A are B and most A are C, then at least one A is B and C. What this says in cardinalities is

\[|a∩b|/|a| > \frac{1}{2} \]  \[|a∩c|/|a| > \frac{1}{2} |a∩b∩c| ≥ 1\]

This is true by Boolean algebra and arithmetic.

The logic of comparison is the underlying logic of game modalities, causation, and probability. It properly includes the regular existential-universal logic of ability. (This is easy to see from the paraphrase of most as a majority. The difference is that there can be many majorities, but at most one between p and ¬p).

There is an equivalence between the exception quantifier all but one and the nonmonotone substitution connective except in

All except one voted yes.

All voted yes except one voted no.

In the former, the exception is handled in a monotone fashion by subtraction inside the quantifier condition. In the latter, an exaggeration is first asserted and then another assertion subtracted from it. It just goes to show that reference events to which truths are compared are no different from the rest: they are event types too.

An example of a dyadic binary quantifier is Kamp’s Most lovers will eventually hate each other. What is counted and compared is pairs of people. A simpler example is Most of you have met. If means anything definite at all, it may be that less than half of pairwise handshakes remain. It is entailed by the situation where a majority of the people are mutually acquainted.

My feelings about the famous donkey sentences have changed with the years (Hintikka/Carlson 19??, Westerståhl 1989). In Two men who have two children each love only one of them there are (at least) two men, at least twice that many children, but one loved child per man. These sums come about if them means the children they have. Also Every man who has a small daughter loves her most of all is not a ban on twins if it is a truth about one-daughter fathers. The bottom line may be that most language users never bother about such niceties, so there is no one truth of the matter to be found.

Logical typology of tense and aspect

Here are some typical questions of the logical typology of tense and aspect.

How many distinct event types can be defined in terms of a given set of constructors in the event calculus? Some results can be obtained applying the theory of regular languages. Particularly interesting is the family of noncounting languages where a xa"y is in the language just when xa"xy is in it. In other words, the language cannot count adjacent occurrences of the same factor beyond some maximum m. Now a = a’ is the defining property of noncount i.e. open event types. Permanences are of form aa", i.e. they require at least two observation points. At least two is expressible in first order.

What are the event types definable from just one open event type a? We obtain two open event types: a and its pointwise complement ¬a, and four closed ones, the half-closed event types a¬a and ¬aa, the cycles a¬a and ¬aa¬a. By the noncounting property, the next longer event types ¬aa¬aa, a¬aa¬a, a¬aa¬aa, ¬aa¬aa¬a are, by the noncounting property, of type (¬aUa)+, i.e. series. The construction iterates through the same set of seven event types on levels of increasing granularity. This is how habitual aspect comes about as a higher order series. pf" a.

Further event types are obtained by adding the abstraction operator as a constructor. The abstraction operator appears in the definitions of the progressive and the perfect. This constitutes another proof of the relative complexity of these aspects.

Do open and closed event types exhaust all event types? In topology, open and closed sets do not exhaust all subsets of a space. In two dimensional time, we must include half-open event types. If we further assume that definable event types consist of simply connected events and their joins, the result is already close.

What is the logical expressive power of different subsets of my calculus? An upper limit for the regular subset is obtained from descriptive complexity theory. Büchi’s theorem proves that finite automata are characterised in monadic second order logic on finite models (Büchi 1960).

shows that Kamp’s propositional temporal logic characterises *star free* courses of events. The higher powers comes from the stars, not unexpectedly. The Kleene calculus is thus properly stronger than first order temporal logic. It has not been shown yet that extra mileage of the star is actually used. An event type only expressible with the star (not expressible in first order) is *knock an even number of times* (\texttt{knock.knock}). It is the same as *keep knocking twice* \texttt{pf* knock}.

From an inconclusive mental survey, I venture the conjecture that *aspect does not count*. Grammaticalised iteration and reduplication constructs generally only make a difference between *once* and *often* (at least twice). Where that holds, we can make do with just Booleans and concatenation, capturing the recucible use of the star with a definition (Pin 1997). It may thus be that the extra power cannot be harnessed with the event types, aspects and tenses which generally get grammaticalised. That would be a vindication of sorts of first order temporal logic as a theory of grammatical tense. The rich algebraic literature on rational languages may find application to natural language here (Perrin 1984, Perrin/ Pin 1986, Pin 1991).

The first example of a non-Priorian first order tense (or aspect) is the progressive defined by Scott (1970) as truth for an open interval: there are two points so that the simple tense is true at all points between them.

### Logical typology of tense

In first order logic, there is a finer hierarchy of concepts expressible in a given number of first order variables. Priorian tenses are expressed in one event and two time variables \((t < u)\). The near tenses or phasal aspects *henceforth*, *hitherto*, *for the near future*, *lately* and their duals involve one event variable and three time variables. None of these suffice yet to express all first order definable tenses (Burgess 1984:117).

Kampian tenses use two event variables and three time variables (van Benthem 1996) to express *since/until* or their dual between \((t < u < v)\). *Next* is definable as *nothing in between*. Concatenation is or continuity are properly stronger than linear order.

Kamp (1968) defines tense as any function from sets of reals to sets of reals (a set of times is a tensed proposition so tenses are propositional operators). Kamp’s theorem shows that all first-order definable tenses on the real line can be defined in terms of two-place tenses matching the temporal adverbials *since* and *until* (Kamp 1968, 1980:136, Lewis 1973:§5.2, Åqvist et al. 1978, van Benthem 1986:102).

Lewis (1973:110) neighborhood semantics for comparative possibility allows defining slightly weaker versions of *since* and *until*. Kamp’s theorem requires the stronger versions. Letting 1 stand for logical truth, we can define near tenses in terms of *since/until* (Burgess 1984:117):

\[
\begin{align*}
\text{lately } p &= p \text{ since } 1 \\
\text{recently } p &= \neg\text{lately} \neg p \\
 p \text{ for a while } &= p \text{ until } 1 \\
\text{immediately } p &= \neg(\neg p \text{ for a while}) \\
\text{henceforth } p &= \neg(1 \text{ until } \neg p) \\
\text{hitherto } p &= \neg(1 \text{ since } 1 \neg p)
\end{align*}
\]

*Since*, *until*, *lately*, *recently*, *immediately*, *or for a while* are instances of topological tenses (in the logician’s sense of the word). Topological tenses essentially assert or deny the existence of a neighborhood at which an event holds (Burgess 1984:117).

There are corresponding subdivisions within noncounting (star free) languages. This is my reading of the situation: The class of piecewise testable events (languages of concatenation level one, Simon 1975, Pin 1994:46) capture Priorian tenses. The dual class of locally testable events capture aspects. Having both gets noncounting events (Salomaa 1973:51). Noncounting events are precisely the first order definable event types, so they correspond to Kamp’s first order definable tenses. Compare the distinction between *safe* and *live* event types, or the distinction between ID and LP rules in grammar.

The relation of Priorian tenses and topological aspects has been studied from above by van Benthem (1986), who develops a logical typology of tense and aspect on the real line using denotational constraints to narrow down the set of possible tenses. Let \(t\) be a Kampian tense, i.e. a mapping between times. Among the conditions van Benthem considers are

**Quality:** \(t\) is invariant under order-preserving automorphisms \(h\) i.e. \(ht = th\)

**Continuity:** \(t\) preserves arbitrary joins and meets, e.g. \(tU = Ut\)

---

\(^{270}\)Finite state power can be added to temporal logic with fixpoint operators (Vardi 19??).
Quality entails that tenses are qualitative: they preserve the order but not necessarily the metric of time. Continuity means that tense cannot change aspect (topological properties, including openness and boundaries, are preserved). Bentham (1985: shows that the tenses that satisfy both quality and continuity are precisely the Priorian tenses. All Priorian tenses can be defined as unions of the past, present, and future of a proposition p. These tenses obviously satisfy continuity: \(< U p = U < p.\)

The progressive does not satisfy Bentham’s continuity, for it maps regions to open event types but fails on points (it removes boundaries from closed events, leaving the interior, if any). Bentham’s continuity condition is really continuity in discrete (Boolean) space, for it does not distinguish open and closed sets. One weakening is van Benthem’s (1985,1986)

\[ \text{Bounded continuity: } tp = tq \text{ for some bounded convex subset } q \text{ of } p. \]

This distributes the tense down to some unspecified minimum resolution. A more illuminating weakening is to constrain closure over joins to open sets, or the following version:

\[ \text{Topological continuity: } t \text{ preserves closures, i.e. } t cl e \subseteq cl t e \]

where cl is the topological closure operator. For instance, the interior and closure operators satisfy the above condition, i.e. prog pf e \(\subseteq\) pf prog e.\(^{271}\) The weakened continuity condition characterises event types which are composed of finite joins of convex periods.

Bounded continuity allows all tenses and aspects formed by taking finite unions of the Priorian tenses, the future and past near tenses, plus aspect operators for the interior, initial and final boundaries, and the beginning and end of an event. This yields seven basic topological tenses/aspects.

Weakening continuity further to monotonicity includes first order definable tenses, like the temporal connective until. (van Benthem 1986:104)

These results obtain for real time. In discrete integer time, metric tenses like tomorrow and yesterday also satisfy quality and continuity (for the simple reason that all automorphisms in a discrete space are continuous). Further results concerning interval structures are reported in van Benthem (1982). A logical typology of possible tenses can be obtained from definability results of this type (Benthem 1986).

A counting theorem about Priorian tenses is Hamblin’s fourteen tense theorem which shows that there are fourteen distinct Priorian tenses definable on the real line (sixteen counting the present tense p and its negation, Burgess 1984:106, van Benthem 1985:9, 1986:101). These are all sequences in (past|future \(\times\) in|for)\(^{2}\) of at most two different tenses from past vs. future, existential vs. universal. All the rest reduce to these possibilities. By Hamblin’s theorem, sequences of tenses longer than two must express something else than just existential or universal quantification over the time line. And as a matter of fact they do: we have definite tenses, topological aspects, and modalities.

These results pertain to linear time. There is an infinite number of Priorian tenses on partial orders, corresponding to different turns to take at branch points (Gabbay 1981, van Benthem 1991:208).

The seven topological tenses are the first order tenses definable using formulas with three indices and two event variables. The number of irreducible combinations of these Kampian tenses is infinite (Prior 1967:108). These results constitute something like a transcendental deduction of the grammatical division of labor between Priorian tenses, topological aspects, and Kamp’s temporal connectives.

Reichenbach’s system obeys a nine tense theorem typical of tense logic with three indices (speech time, reference time, event time). This count only varies the relative orders of the indices, not quantifier character or aspect. It could be a useful exercise to calculate the theoretical total here.

On a more empirical slant, one can ask whether a given natural language tense system is combinatorially complete in some sense analogous to Kamp’s theorem. As Declerck (1994:138) notes, not all temporal relations that exist in reality need be expressed by the tense system. But can they?

Any imaginable temporal relation is effable one way or another. To have a tighter game, one should restrict the system, say to grammaticalised tenses only. But that too is a slippery slope. All Kamp’s senses surely cannot be expressed in one clause of any natural language. But one can consider how tense systems divide up the time line.

Frawley (1982:358) distinguishes six logical possibilities for encoding finite tenses:

1. Three-term system: past, present, and future all encoded differently: e<now, e\(\cap\)now, now<e
2. Two-term system:
   a. past and present encoded alike vs. future e\(\cap\)now, now<e

\(^{271}\) In discrete spaces, closures are open so that \(U t = cl t.\)
b. present and future encoded alike vs. past \( e<\text{now}, \text{now}\leq e \)
c. past and future encoded alike vs. present \( e\setminus\text{now}, e<\text{now}\cup\text{now}<e \)

3. One-term system: past, present, and future all encoded alike. \(<e<\)
4. Zero-term system: past, present, and future not encoded at all. \( e\)

According to Frawley, 2c and 3 are unattested, while 1 and 4 are rare. Most languages make a two-way finite tense distinction into past-nonpast or future-nonfuture. Past/nonpast or prospective systems are familiar from Indo-European. Future/nonfuture or retrospective systems are found in Amerindian and Oceanic languages. The scarcity of systems symmetric around the present is another exponent of temporal asymmetry (Ultan 1978, Chung and Timberlake 1985, Bybee 1985:158).

Frawley (1992:362) subsumes the absence of present-nonpresent tense systems 2c under an observation by Keil (1979) that regions on ordinal scales in general get split into connected regions. Comrie (1985) and Bybee et al (1994) also note the absence of tenses denoting a discontinuous region.

The next level of refinement will distinguish near and remote tenses. Simple past \( e<\text{now} \) has remote past \( e<\text{now} \) and immediate (near) past \( e\text{now} \) as special cases.

The following figure maps various regions around a given reference time. The figure does not do justice to the calculus in that it does not properly reflect distinctions between presupposition and focus or between tight vs. loose event type. It also misses that compound tenses like past progressive or future perfect make fewer distinctions around a second reference time. A tense system corresponds to a selection of forms from the grid. Legend: light shade marks focus, dark shade background. Temporal precedence relations are entailed between focus and and background, not between background bits. Dualities are not indicated.
<table>
<thead>
<tr>
<th>past</th>
<th>near past</th>
<th>past present</th>
<th>near future</th>
<th>then</th>
<th>future</th>
<th>then</th>
<th>future</th>
<th>future</th>
<th>near future</th>
<th>future</th>
<th>future</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; then</td>
<td>&lt; then</td>
<td>then</td>
<td>&lt; then</td>
<td>&lt;</td>
<td>&lt;</td>
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<td>&lt;</td>
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<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
</tbody>
</table>

Table 86
Metric tenses come about through the choice of granularity for the neighborhoods involved in the distinction of near and remote tenses. For instance, a hodiernal tense is a present tense, a hesternal tense a near past on a daily calendar. The English next past used to seems to implicate that the past event has been over for the near past. (This may be a defeasible implicature only.)

**Tense and aspect reductions**

The most complex tense and aspect combination which has enough currency in English to be included in grammar books seems to be would have been Ving, i.e. the past future of a perfect progressive. Why are there just those combinations that there are? A large share of such combinatorics falls out from the logic of tenses and aspects (Burgess 1984:95). Obviously, the combinations in use must make some sense. By Hamblin’s theorem, many combinations do not, because they are inconsistent, redundant, or vacuous, or perhaps just because they are too complicated. Here are some reduction results of this sort:

- **perf fut e = fut e**  
  the perfect of future reduces to future.

- **perf past e = past e**  
  the perfect of past reduces to past

- **perf perf e = perf e**  
  the perfect of perfect reduces to perfect

- **past past e = past e**  
  the past of past reduces to past

- **past perf = past e**  
  the past of perfect reduces to past

- **fut past e = past fut e = sometime e**  
  the future of past equals the past of future equals anytime.

- **prog perf e = perf e**  
  progressive of perfect reduces to perfect

- **p = prog p**  
  progressive reduces to simple aspect for processes

**Table 87**

Up to equivalence, iteration of existential tenses of the same type produce no new tenses (Hamblin), and composition of opposite tenses does not fix the position of an event to now (Kamp). Therefore composite tenses make a difference only if the intervening event is anchored to another reference time, either in the past (pluperfect and past future) in the future (future perfect). A derived motivation (found e.g. in the use of pluperfect in Indian English influenced by Hindi, Comrie 1985:69) is to create a contrast between near and remote tense.

Chung and Timberlake (1985) note regularities in the use of aspects to express relative tense in contracted clauses. These entailments are straightforward corollaries of the calculus. The left column formalises the aspect, the right column its temporal entailment.

| Present perfect becomes past:            | perf e\|now entails e≤now |
| Nonfuture perfective becomes past        | pf e\|now entails e<now  |
| Nonpast perfective becomes future        | pf e\|now< entails now<e |
| Imperfective becomes present             | ipf e\|now entails e|<now< |

**Table 88**

Why do many languages have a pluperfect but few if any really have a second future like the hypothetical Latin morituri erunt ‘they will be going to die’? Few languages have a future participle to start with. This must have to do with the asymmetry of time toward future. The perfect mortuus has a beginning: there is an identifiable event, dying, after which one can say Nunc est mortuus, ‘now he is dead’. Moriturus ends with death, but it has no clear beginning: there is no obvious point where Nunc est moriturus ‘now he is dying’ changes from merely possible to necessary. In one sense, it is birth, in another sense, death: every man is mortal, but as long as there is life there is hope. The reason for using a second future can only be perspectival, to discuss the future from the point of view of another future or to distinguish two future modalities (say, an epistemic and a deontic one). These needs do not seem salient enough to get grammaticalised.
It follows from aspect definitions that perfective and imperfective aspects (have readings under which they) are idempotent, so sequences of similar aspects reduce to an alternation of dissimilar ones. More generally, as logicians have noticed, similar quantifier or operator prefixes reduce to alternations of dual weak and strong operators (the prenex hierarchy, Bentham/Doets 1983:309). Lindstedt’s (1985:198) alternation principle falls out as a special case.

A generalisation that can be subjected to detailed test given a calculus is that grammaticalisation follows a falling slope of logical complexity. Open class words (even), including adverbials (regularly), temporal conjunctions (since), aspects, and tenses express progressively simpler quantificational conditions (Burgess 1984).

**Duality of tense and aspect**

There is a duality within the class of star free (noncounting) languages which is relevant for tense and aspect. Languages of concatenation level one express temporal precedence, but not adjacency (Pin 1997). Dually, locally testable languages can express aspects and near tenses, but not Priorian ones. All first order properties of time can be represented by combinations (meets) of these classes (Kamp 1968). The two classes are first order definable in the two-variable fragment of first order logic (van Bentham 1996:56). Noncounting or star-free languages are definable in the three-variable fragment, like relation algebras and first order tenses (van Bentham 1996:69)

The basic event types of the aspect calculus are locally testable. Thus locally testable languages characterise natural language lexical aspect. On the other hand, Priorian tenses correspond to languages of concatenation level one. This suggests that the natural language tense and aspect duality is a suitable and complete logic for first order properties of time.

First order logic is well known to have only limited capacity for expressing number. The notion of natural number cannot be characterised in it, for it cannot express the notion of mathematical induction, or closure in general (the smallest set). With identity, it can add, but it cannot do multiplication. It does not capture arithmetics (no half-way computable system does). Monadic second order logic brings in automata, iteration, induction, and even and odd.

Logic in general involves Boolean algebra (propositional and monadic predicate logic) and its generalisations (relation algebra, cylindric algebra). The one thing that distinguishes Boolean algebra from arithmetics that it too does not count. Due to idempotence $aa = a$, Booleans only count to 1 before cycling.

First order logic cannot distinguish two elementarily (bisimulation) equivalent states/automata. The automaton for the language $(aa)^*$ has two distinct but elementarily equivalent permutation invariant states. The quotient of the automaton under elementary equivalence collapses the two states into the one-state automaton for $a^*$. First-order event types correspond to star-free languages and aperiodic automata, or groups with cycle length $< 2$. It is a good question how complex event types get lexicalised in natural language. Are there words in natural language for periodic event types of form $(aa)^*$?

Now here is an interesting thought. There is a optimality theory universal known as obligatory contour principle (OCP) which rules against sequences of identical copies of elements of any tier in grammar. My conjecture is that what the obligatory contour principle is good for is to make sure that language stays noncounting. For instance, consider a rule which adds a stray syllable to fill out any catalectic trochaic foot. This rule, if it is applied along words of arbitrary length, is not noncounting (it requires that the output word is of even length). But if we require that words have alternating feet, the problem reduces to making sure that the last foot is not odd. This is a locally testable condition!

**Logical typology of mood**

Semantics for modal logic can be based on binary relations, set functions, and Boolean algebras, respectively known as relational semantics (Kripke), neighborhood semantics (Segerberg), and algebraic semantics (Bull), with increasing expressive and decreasing explanatory power.

Within each type, finer structure comes about as constraints on the basic model class. The logical typology of modalities known as modal correspondence theory is a well charted area (van Benthem 1997??). Such results provide insight into the system of logical metaphors in the domain of mood, with a well defined set of morphisms from the more complex systems to the less complex.

A dual aspect is the logical metonymy of modality, or modal prototype theory. I have proposed the game theoretical model (Carlson 1994) as a prototype or canonical model of natural language mood and modality (van Bentham 1985:27). It represents a minimal model in which the modalities involved in planning and agency can be meaningfully defined so that their conceptual connections become clear. These are also modalities found in natural language expressions of the future. These modalities together constitute a framework of concepts for rational action, whose natural models are decision trees, or game trees, of the sort shown in the picture (Carlson 1994).

It seems an important old generalization about natural language modalities that mood concerns future: modalities which become grammatical moods start out from the branching future of possibilities. In a minimal system of tense, mood, and aspect, mood and future are one and the same thing.
In the temporal dimension of the tree, we can define tenses and aspects. In the modal dimension, we can define possibility as the presence of an event in some alternative course of events. It does not really matter what sort of possibility it is. Natural language modalities are essentially contextual: the basis of possibility and necessity varies with the context (Kratzer 1977, 1978, 1981). Hence it is no wonder that it is often impossible to tell in a given case just what modality is involved (Bybee et al. 1994:187). Possibility is possibility relative to some theory, consistency with some set of premises, and necessity is what follows from them. This idea is well known in modal logic (Hansson 1969): different modalities can be represented through one generic necessity operator relativised to different sets of premises. (Benthem 1985:17).

Call the generic modality root modality in deference to linguistic tradition. What is possible and what is not determine the boundary conditions of the decision situation, the rules of the game being played. They can be redefined at will.

Three major varieties of possibility which get singled out in natural language grammars are dynamic, deontic, and epistemic possibility (von Wright 1968, Palmer 19??). Dynamic possibility involves what the player is able to do given his powers and skills. Deontic possibility concerns what someone (else) prefers (for one to do). Epistemic possibility is what is compatible with one’s knowledge and beliefs.

What an agent is able to bring about are those things which he knows how to bring about: one has a plan, a means for one to ensure the outcome (Moore 1981, Carlson 1994).

Goals, i.e. preferred outcomes or future courses of events, are defined as choice functions in the set of alternative futures. Epistemic possibility is consistency with my knowledge of the situation. Uncertainty also extends to other (players’) possibilities (plans, abilities), so it naturally scopes over the other modalities.

Since can is an existential-universal or regular modality, dynamic possibility falls logically between possibility and a necessity, because it has two simple modalities in a row: there is a strategy so that all future courses compatible with it make something true. Can in the dynamic sense be able is the prime verb for dispositions (abilities, capabilities, tendencies, propensities).

The analysis of dynamic modality as an existential-universal type modality ‘it is possible (for me) to make it necessary (for others) relates it to dispositions and counterfactual conditionals: there are certain conditions which if true, will necessitate something. This connection has been studied in Lewis (1973). A disposition supports a universal conditional, and when the condition holds, the consequent is realised. The Greek conditional/modal particle an is glossed ‘under given conditions’, hence also ‘possibly’ (Kühner 1896 §392.5.)

A fairly established view on the logic of counterfactual conditionals is that they are based on comparative (order) relations, analogous to the quantifier in most cases or in the most X cases along some comparative notion X. This entails that their semantics, like that of most, is not first order definable (van Benthem 1986:92).

By the possible worlds definition, possibility is the existence of conditions (a “possible world”) which make something true. If the conditions hold, the possible event does too. Cans are constitutionally iffy (Austin 1961), but obtain a success sense when the ifs become true.

Control means symmetric ability, Aristotle’s eadem potentia oppositorum. Its dual is contingency: neither the event or its complement can be prevented. A contingent event just happens, it happens uncontrollably or accidentally. Given the Aristotelian connection between agency and reflexivity, one can also construe the duality able/happen is as a voluntary/involuntary pair of reflexive causation: one who does something by itself voluntarily is able to do (what he wants), where one who does something by itself without wanting it just lets himself do it.

The interchangeability of a past weak modal with existential perfect use here is an example of the Diodorean chronological interpretation of possible as some time (Hintikka 1973). Recall also the characterisation of control as symmetric ability and freedom through the relation algebraic reflexive residual self\(\cap\)can.do=want x can do what x wants.

An algebraic representation for the tree of possibilities can be obtained through the notion of strategy set, which represents a game tree as a union of choice functions for the various branch points. A strategy set in turn corresponds to a disjoint join \(\Sigma\sigma\) of priority joins. The outcome of a play is a meet of such strategies. (Carlson 1994).

The root (dynamic), preferential (deontic), epistemic, temporal and logical modalities on the tree of possibilities represent progressive reducts of strategies. This affords us one way of mapping the network of morphisms between modalities which guides the evolution of natural language moods.

Logical typology of diathesis

There is an inherent arbitrariness to taxonomy given a calculus. It is the arbitrariness of choosing one tree or grid from among a legion. An example: one tradition from Aristotle through Vendler divide events into four types: states, activities, achievements and accomplishments. Genusiene (1987:34) makes a four-way distinction between states, activities, inchoatives and causatives. Are these the same fourfield?
Classifying cases is partly arbitrary, especially going into smaller classes. There are almost always different but compatible ways of looking at the same example, all covered by the general rule. (Compare classifying discourse uses of a pragmatic particle, Carlson 1984). On the plus side, typology comes for free in a calculus. You don’t have to give names to all diathesis types, if they just are all the types which the calculus allows. The calculus itself is a generator of complex names for types. One does not have to try to find one family tree to rule them all.

I start out from an abstract statement of what it is to be a diathesis type in terms of the category theory diagram of product, its dual and its projections, then relate it to corresponding notions of combinatory logic and relation algebra. Then I start complicating the picture with more complex combinations of combinators on more complex, less logical relations which preserve fewer morphisms. For logic too is a graded notion, depending on what is preserved in morphisms.

There are good logical reasons why just those operations should play an important role in diathesis typology which do. Reflexive and passive are the only logical (quantitative, permutation invariant) argument reductions, corresponding to the logical relations identity and cartesian product (Keenan/Faltz 1985, Westerståhl 1989:114, van Benthem 1991:91). Conversely: Booleans, identity, cartesian product, and composition form the permutation invariant argument place constructors.

### Diathesis as combinator

Diathesis combinatorics bears scrutiny from a combinatory logic point of view. The operators change and cause are instances of composition B. The operators become and pass are instances of right projection R. The antipassive operator act is an instance of left projection L. The reflexive operator refl is an instance of duplicator W. The medial operator refl let is an instance of distribution operator S.

Concerning the paradigmatic typology of diathesis systems, the question of combinatorial completeness can again be raised. Combinatory logic or relation algebra provide answers to the question which selections of diathesis operators are combinatorially complete, i.e. allow expressing all permutations of arguments. These results can be compared to the systems of diathesis combinators actually found in natural languages.

For instance, the combinator F appears as an argument raising operator \( F O p q x = O p x q x \) that matches the English subject control constructions and the serial verb construction in languages like Chinese or Twi:

Kofi de pono no baae. Kofi take table come  'Kofi brought the table.'

A more radical research program is to compose natural language morphology and grammar directly from combinators, perhaps implemented by regular transducers (Roche 1997).

Reflexive, (agentive) passive and causative diathesis form a natural language version of the calculus of combinators W, C, K and B.

Passive as a phenomenon involves cancellation (K) and conversion (C). K cancels an argument (sets it to 1), C inverts arguments. Both can happen in a passive construction, but they can be separated as well.

Analogously, we can distinguish active (subject to object) reflexive W and passive (subject to agent) reflexive WC. The latter is the active itself type, the latter the passive by itself type.

Simple combinations of basic combinators already give us a number of central types:

<table>
<thead>
<tr>
<th>left cancellation right projection):</th>
<th>right cancellation (left projection):</th>
<th>copy: object (active) reflexive</th>
</tr>
</thead>
<tbody>
<tr>
<td>impersonal</td>
<td>antipassive</td>
<td></td>
</tr>
<tr>
<td>converse:</td>
<td>left cancellation of converse: passive</td>
<td>copy of converse: source (passive) reflexive</td>
</tr>
<tr>
<td>agent passive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 89
Despite suggestions to the contrary, combinators are not all that natural language like. What is natural language like is having an alternative to variables. What is less so is sticking exclusively to the left-to-right order of evaluation. Natural languages avoid parentheses by having more combinators, or they just allow ambiguity.

A common selection of diathesis combinators seems to be $B$ (causative), $K_1$ (antipassive), $K_2$ (passive), and $W$ (reflexive).

The combinators $B, W, K$ and $K_2$ compose, copy, left and right projection yield a combinatorially complete set of combinators (see section on combinators). It is interesting that no natural language is known to have a morphological combinator for relation converse (Genusiene 1987:334). The closest analogues, agentive passive and reflexive both seem to develop from agentless variants.

More subdivisions are obtained when each diathesis type is detailed into cases by the complexity of the relations and combinators involved. We do not find just one $n$-division, but stepwise refined cross-classification.

**Morphisms of combinators**

The above section defined one matrix of dimensions among diathesis combinators. Another dimension of typing is type-subtype relationships between combinators. At the rarefied end are logical combinators invariant under automorphisms, including those studied in combinatory logic. Under them extends the entire spectrum of event type alternations available in natural languages.

For instance, inasmuch as the relation between *buy* and *take* is a subtype relationship, the logical relation between *buy* and *give* is a subtype of the inverse combinator $CI$, obtained by composing the subtype morphism between *buy* and *take* with the combinator. Similarly, *cause* can be recognised as a subtype of the temporal relation $\leq$, which is a type of binary relation. On the other hand, at the same time, it also represents a choice function through Lewisian analysis of causation. By keeping an eye on these morphisms it is possible to bring logic to the bewildering variety of natural language diathesis.

**Diathesis and relation algebra**

In relation algebra, the universal relation, identity, and relation projections form a four group. When left and right domain equal the field of the relation, $a = b = 1$, intransitive (antipassive), passive and reflexive fall together: $arb = ar1 = 1rb = ara = r$.

For everyone to love someone is for everyone to be loved, for the humanity to love itself. When we are in love, I am in love and you are in love, we love one another and love is between us. All of these metaphors (if they are metaphors) hold at once.

Deletion of an argument of a relation, setting it syntactically to $\emptyset$ (the empty string), is thus dual to making it denote the universe or unit, setting it semantically to 1. The impersonal subject construction *it is raining, there is dancing, they dance*, sets domain (first argument) to 1 in some Boolean algebra. Intransitive (antipassive) *eat* = *eat something* sets codomain (second argument) to 1 in some Boolean algebra.

If $a$ is an absolute object type, then it is equivalent to $aa$ and to $a1$ and $1a$. Which means that it is its own reflexive and/or its own passive. Conversely: if an object type $r$ is its own reflexive and/or its own passive, then it is absolute, i.e. universal in its field.

Examples of one-place predicates with (anti)passive or reflexive morphology are passive resultatives like *broken* or intransitives like *break*. An interesting example is French *il se peut que / peut être (que)*.

1 may $e = e$ may $e = e$ may 1

**Diathesis and causation**

The logic of *cause* and its variants *let* and *become* is involved in diathesis alternations. By the logic of causation,

$e = 1$ cause $e = e$ cause $e = e$ let $1$ cause $e = 1$ become $e = e$ become 1

What just happens is caused by everything, or nothing. (It is not the same as being caused by something.) It causes itself or lets itself be brought about. Because causation is thought to be contingent, so if something is caused by everything, then it is caused by nothing in particular. We say something is caused by nothing or by itself when it is caused by nothing in particular, or everything together.

A noteworthy feature of the above equivalence is that it explains how come adding a reflexive can appear to subtract meaning from a transitive verb (Genusiene 1987:29). This is a consequence of the idempotence of causation: $e$ cause $e$ equals just $e$. 

Consider binary diathesis operators \( \leq \), become and cause as category theoretic products. The mappings from the product to its factors are their projections to the components. Contradictory change is the product of two states. Contrary change is the product of two contradictory ones. Causation is a product of two correlated changes.

The diagram creates a dense network of morphisms between event types. For instance, the earlier theorem showing that become \textit{Ved} is a passive shows up as a commutative diagram here.

An orthogonal dimension of refinement is obtained by multiplying the event diagram with objects participating in the event types. Doing the multiplication at different points of the diagram produces results of different complexity. The extra degree of freedom obtained by multiplying out can be pulled back by imposing identity constraints across factors. For instance, event type \((p.q)x\) distributes to \((px).(qx)\), which is also obtained from event type \((px).(qy)\) by imposing an identity constraint \(x=y\).

**Interdefinabilities of roles**

Grammatical roles are dual to event types. A role is determined by one or more paths in the graph of event types. The typology of roles is thus dual to the typology of events. To get a handle on roles, let me review the typology of event types once more from an abstract perspective.

The most general roles everyone works with are subject, object, and oblique. Subject is the only argument of a one-place predicate, object is the codomain of a binary relation, and an oblique is the object of a preposition, where a preposition forms a predicate out of an object.

I have defined subject as the left argument of the event type be, object as the subject of an effect of a causal event type, and oblique as a nonsubject. Are these different definitions? I say no.

The event type be in turn can be given a variety of compatible denotations, ranging from none (be as a dummy carrier of tense) to identity, inclusion, and existence. The verb include means close in.: y closes x in z, i.e. y cause x be in z. Its reflexive instance is where y closes x in itself, or y cause x be in y. What is the smallest event type of y that causes this? Obviously, the order dual or inversion of x be in y, namely y be around x. Thus the initial object of the event type of include is

\[ y \text{ be around } x \text{ cause } x \text{ be in } y \]

By the duality of in and around and the refexivity of cause, this event type reduces without residue to

\[ x \subseteq y \]

This trick can be generalised. \textit{Any} binary relation arb can also be exactly represented as a cause event between two one-place event types. The representation is simply

\[ a \subseteq a \cdot \text{rb cause b} \subseteq a \cdot r\text{b}. \]

a including b causes b to be included in a. Which means just that a includes b.

The lesson is that roles are relative to event types, and event types commute. There is nothing immutable about roles of subject, object and oblique, they are interdefinable. For instance, inclusion can be represented in many grammatically different, but equivalent ways.

\[ \begin{align*}
(a \subseteq b) &= (a \cup b = a) = (a \cap \text{in } b \times \emptyset) = (a \subseteq \text{in } b) = (\text{in } a \subseteq \text{in } b) = \\
\emptyset \subseteq a &= (\neg b \subseteq \neg a) = b \subseteq \text{in } \neg a = b \subseteq \text{around } a = (b \cap \text{around } a \times \emptyset)
\end{align*} \]

These equivalent variants exhibit a and b in varying roles as coordinate subject, predicate, object, or oblique. The relation of subject and predicate can be represented in Booleans by meet, identity, or inclusion, take your pick.. Identity is symmetric inclusion, meet and inclusion are related by adjointness.

Here are more perspectives on the interdefinability. The left projection of a binary relation is a function which produces a predicate out of an object, i.e. has the type of a preposition.. For instance in is the left projection I \( \subseteq \) of the binary inclusion relation.

The relation of an object y to the prepositional phrases in y (around y) is the relation of an element y of a Boolean algebra to the ideal (filter) generated by it. What is the relation between meet, inclusion and ideal? Simple, ideal is closed under meet and inclusion. The Boolean ideal of x the same as the set of all properties of x so it is dual to x.? It is also the same thing as the Boolean morphism of x on 2. All of these are interdefinable, a small circle of friends. All of these different perspectives come to the same, they are not alternatives to choose from.
**Asymmetries of roles**

We have seen that roles can be inverted freely. Can any sense be made of the idea that one of the senses of a duality is more basic than another? Take for instance the duality of expressions of containment or possession in ‘passive’ and ‘active’ languages. As a speaker of a ‘passive’ language like Finnish, I have a strong feeling that the intransitive expression of containment and possession $x$ be in $y$ and $x$ is with $y$ is more basic than the transitive idiom $y$ contains $x$ or $y$ has $x$.

Why does causative seem to me to be the converse of the intransitive rather than the other way round? Why should being inside something not be a causal relation, but containing something be one? By Newtonian physics, absence of relative acceleration needs no cause, and that applies equally to contents and container. There is something here I haven’t explained yet. Or perhaps I have? On closer thinking, there are many consilient factors which have already been mentioned in other connections.

There is something topological and purely logical about the asymmetry. Topology defines inside and outside, interior and boundary. What is confined within (without) boundaries can’t get out (in). The boundary of a region is closed, its interior is open. Openness is an universal-existential live notion: a region is open if every point has an neighborhood in it. Closure is an existential-universal safe notion: a closed set contains its boundary, the set of its limit points. To be closed is to contain, be able to prevent, to be open is leak, have to let the inside get out.

To cause something is to be able to bring about something, equivalently, to prevent something. A container contains what is inside it, prevents it from coming out. This makes intuitive sense, and makes physical and biological sense too: liquids and gases want to expand, live things want to move about, so containment entails application of force on them. The second law of entropy, or the arrow of time, is involved: things that move by themselves by nature want out and disperse, unless a container contains them.

$$\text{1 cause } x \text{ be in } y. x \text{ be } \neg \text{ in } y$$

Through inclusion, size gets into this too. Small things move in and out big things, big things stop small ones from moving in or out of them. Small things seem to move relative to big things by sheer proportionality of sizes, masses, and motions. Whether small things move or not does not affect big things, while big things can affect small things by controlling their motion. Small things are agents, big things are environment. If small things move by nature, big things by nature stay in place:

$$\text{1 cause } x \text{ be at } y. x \text{ be at } y$$

These Aristotelian simplifications are instances of genericity.

**Diathesis calculus**

Genusiene (1987:§4) develops a calculus of argument reduction for transitive verbs. She studies the combinations generated by the transitive roles subject and object as input and four roles, subject, object, oblique and zero as output, and consider all sixteen possible mappings from 4 to 2, 16 cases. Of these eight are not attested. Excluded are all four cases where subject maps to object. Object goes to oblique or zero only if subject stays subject. To put it positively: eight cases survive. Included are all four cases where subject stays subject and object comes up or goes down. Included are also the four cases where subject goes down and object does not.

Genusiene’s approach proceeds top down, excluding possibilities by constraints. The dual method is to build the existing alternatives bottom up. Here is one way, taking monadic plural event type as base. The code on the left corresponds to Genusiene’s.

<table>
<thead>
<tr>
<th>Genusiene 1987</th>
<th>event type</th>
<th>transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject-subject</td>
<td>(a and b) be together = (a and b) be with 1 = (a and b) be with (b and a)</td>
<td>identity</td>
</tr>
<tr>
<td>subject-oblique</td>
<td>a be with b = (a be with b) and (b be with a) = (a and b) be with (b and a)</td>
<td>distribution</td>
</tr>
<tr>
<td>subject-zero</td>
<td>a be with 1</td>
<td>distribution, oblique to unit</td>
</tr>
<tr>
<td>oblique-subject</td>
<td>b be with a</td>
<td>distribution, conversion</td>
</tr>
<tr>
<td>zero-subject</td>
<td>b be with 1</td>
<td>distribution, conversion, oblique to unit</td>
</tr>
<tr>
<td>subject-object</td>
<td>a have b = a have b with a = a cause b be with a</td>
<td>distribution, conversion, causative</td>
</tr>
</tbody>
</table>
oblique-object  
I have b with a = a have b with a =
a cause b be with a
distribution, conversion, causative, subject to unit

zero-object  
I have b
distribution, conversion, causative, subject to unit

Table 90

The transformations on the left is a selection of many combinatorial options. The lesson again: there is not just one classification of event types, but a group of symmetries.

Number Genusiene’s four roles from 0 to 3 as subject=3, object=2, oblique=1, zero=0. Then think of the numbers 0-3 as a Klein four-group so that subject is 11, object is 10, oblique is 01, zero is 00. What then are the two axes? Subject-predicate distinction is the first bit, for it distinguishes subject and oblique, oblique being the predicate position. subject-object distinction is the second bit, for it distinguishes that one. What is the relation between the first division, subject-predicate, and the second division, subject-object? How do we get to two-place relations from two binary divisions? One way is by the causation transform $xry = x p cause y q$. Subject of transitive is subject of cause, object of transitive is subject of effect. Argument lowering from object 2 to oblique 3 in terms of the $x p cause y q$ equality amounts to the inversion of effect $y q$ to $q y$ so that $y$ becomes a non-subject after being a subject. For instance $a have b = a with b cause b with a = a with b cause a with b = a with b$, which is just the subject-oblique event type.

Logical typology of reflexives

Genusiene (1987) proposes a three-level diathesis calculus of reflexive event types. Is there a counting theorem on the number of logically possible reflexive diathesis types in the offing? Indeed, her Table 8 (p. 230) lists fifteen reflexive event types and suggests that they should be the lot.

The problem with counting theorems is that the count depends on the partition, and is just as interesting as the partition. I find it significant (and correct) that examples cannot be uniquely classified under types (Genusiene 1987:§2.1.3.3). It is just what one can expect from a calculus.

Let us survey Genusiene’s fifteen types of reflexives, or sixteen, since one type has two cases. The left side shows one of my event types which is compatible with Genusiene’s example.

<table>
<thead>
<tr>
<th>x cause y cover x with y</th>
<th>Ona nakrylas’ odejalom ‘She covered herself with a blanket’</th>
</tr>
</thead>
<tbody>
<tr>
<td>x squint y of x</td>
<td>Ona prishchurilas’ ‘She squinted (her eyes)’</td>
</tr>
<tr>
<td>x cause x bite 1</td>
<td>Sobaka kusajetsja ‘The dog bites’</td>
</tr>
<tr>
<td>x throw x forward</td>
<td>On brosijaja vpered ‘He threw himself forward’</td>
</tr>
<tr>
<td>(x and y) kiss (y and x)</td>
<td>Brat i sestra pocelovalis’ ‘The brother and sister kissed (each other)’</td>
</tr>
<tr>
<td>x cause x throw 1 with y</td>
<td>On brosijaja kammjami ‘He is flinging round with stones’</td>
</tr>
<tr>
<td>x cause x dig 1 in y</td>
<td>On rojetsja v jane ‘He is digging in the hole’</td>
</tr>
<tr>
<td>x let 1 break x</td>
<td>Steklo razbilos’ ‘The glass broke’</td>
</tr>
<tr>
<td>x let 1 open x</td>
<td>Dver’ otkryvajetsja legko ‘The door opens easily’</td>
</tr>
<tr>
<td>x let 1 build x by y</td>
<td>Dom stroitsja sodom ‘The house is (being) built by the neighbor’</td>
</tr>
<tr>
<td>1 cause x want y</td>
<td>Mne xochetsja jablok ‘I want (feel like eating) apples’</td>
</tr>
<tr>
<td>x let</td>
<td>cause 1 reflect x in y</td>
</tr>
<tr>
<td>y let</td>
<td>cause x hear y to x</td>
</tr>
<tr>
<td>1 cause 1 shave x</td>
<td>pl Mojego kolegemi goli siem v domu ‘They shave my colleague at home.’</td>
</tr>
<tr>
<td>x let y shave x by y</td>
<td>On pobrilsja u parikmaxera ‘He had himself shaved by a barber’</td>
</tr>
<tr>
<td>x cause y become tame to x</td>
<td>It Jis pri(ii)jaukino lapem ‘He (has) tamed himself a fox’.</td>
</tr>
</tbody>
</table>

Table 91

How do my assignments here compare with Genusiene’s?

Genusiene’s calculus is conceived as a calculus of role reductions from a transitive prototype, geared for nominative-accusative languages. The unreduced case is a transitive event type with two referents, in semantic roles of subject and object, in grammatical functions of subject and direct object. A reduction can show in the number of arguments, in the assignment of semantic roles, or in the assignment of grammatical functions. A “deeper” change causes more “superficial” ones, but not conversely. The last type 15 does not really belong here because it is not distinguished by Genusiene’s criteria. It portrays a medial (dative or oblique) reflexive.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref1</th>
<th>Ref2</th>
<th>Sb</th>
<th>Ob</th>
<th>S</th>
<th>DO</th>
</tr>
</thead>
</table>
### Table 92

Start from the referent columns. Referent 2 is identified with 1 in Genusiene’s types 1 (semantic reflexive) and 3 (autocausative). They differ in that type 1 keeps the semantic role of object, type 3 does not. Direct object disappears in both. Type 1 allows instrument role, type 3 does not.

Referent 1 is nullified in type 7 (decausative), and with it the subject role. The remaining argument appears as grammatical subject. Not unexpectedly, there is no event type where object binds a reflexive subject. That exhausts the explanatory potential of the referent columns.

Looking at the remaining marked cases in the role columns, there are two cases where both arguments play both roles. One is type 4 (reciprocal), where subject and object become a joint subject. The other is the reflexive factitive type 14 (reflexive causative), where object becomes subject and subject oblique. Two types reveal a place role, namely type 6 (deaccusative) and type 11 (converse). They pair up as quirky cases of antipassive type 5 (deaccusative too) and type 9 (reflexive passive), respectively, where the oblique is in instrumental case. This takes care of the role columns.

The remaining eight types are distinguished by grammatical columns. The two variants of type 2 (partitive object and absolute) are not distinguished by Genusiene’s criteria. Their event types above look quite different, but can be made more alike by rewriting the former as x squint (1 of x) and the latter as (x bite 1) of x (the dog bites anyone of itself).

### Table 93

These thus form natural classes with their transitive counterparts. Variants 9 and 13 together constitute a class of impersonal passives or reflexives. When x is the target of a misfortune, type 12 is adversative: es se me rompió el pantalon ‘my trousers got torn on me’ (Genusiene 1987:275).

Though the counting theorem is open for reconsideration, what about Genusiene’s claim for combinatorial completeness for Table 8 (Genusiene 1987:234)? Does my recast of her calculus give grounds for a combinatorial completeness theorem for reflexives?
Symmetric event types

Let us get back to the question why eight cases in Genusiene’s calculus do not appear. There were no instances of subject to object reduction in Genusiene’s 50 language sample (Genusiene 1987:225). Among less striking things, it means that the sample contained no example of a natural language converse operator which would simply swap the roles of subject and object of a transitive sentence.

If there is no such case, perhaps there cannot be? Remember that cause is token asymmetric: if event token e causes c, then c does not cause e. The converse y -hit x of an active transitive event type x hit y cannot be active transitive, because if (x swing cause y hurt) at t is nonempty, then (y hurt cause x swing at t) is empty. The converse of an active transitive must be passive. By the same token, if an event type has a true converse, then it is not active transitive, but symmetric. Contact verbs are a case in point. Verbs meet, join, touch, hit are self-converses precisely when equivalent to plural reflexive (reciprocal) x and y meet.

Contact verbs form families with closely related meanings where causative and reflexive derivatives overlap in meaning. Be able/happen modalities frequently arise here. (Compare Latin accident and coincidence). If less symmetric event types implying contact like come, get, follow, take, catch and grasp are counted in, this is a big class of event types.


Reflexive event types

Genusiene (1987:37) notes that reflexives are mostly derived from causative verbs and rarely from states (excluding dynamic states, which are reflexive causatives to start with). Obviously, to identify arguments there have to be at least two to start with. What other types of binary relations do natural languages code besides causal ones?

Well, there are symmetric ones describing two different things together, or with one another. Then there are comparative order relations of one thing smaller than, before or inside another. Both types of relations are irreflexive, so they do not lend themselves well to reflexivisation. Two things cannot well be one, nor is anything easily smaller than itself. But never say never: one can withdraw to oneself, be beside oneself, wrapped up with oneself, not like oneself, or surpass oneself.

Image relations in general reflexivise with no difficulty, for original is at once one with image and another thing. A mirror can reflect itself and so can we; we love ourselves and should know ourselves. Relations of wholes and parts are a source of reflexives too: one can touch, see or feel oneself by one part being in contact with another. As it happens, words for self etymologically derive from words for shape, shadow, body or soul (Genusiene 1987:241).

Regular algebra for TMAD systems

The logical next step in logical typology of tense-aspect systems is to formalise the TA systems of different languages by translating them into TA primitives and study and compare the expressive power of the resulting systems.

Guillaume (1927) represents the Latin TMA system as a geometrical drawing. In one projection plane, there is the present/perfect aspect distinction in infinitives. In the center projection, there is a square representing the four forms of the subjunctive. In a third projection plane, there are the six forms of the indicative.

I shall try to replace Guillaume’s figures with algebraic ideas. Recall that aspect operators can be formally represented as transducers mapping event types into event types. The calculus of aspect operators in turn forms a regular algebra with composition as concatenation and the identity mapping as the identity element (Karttunen/Beasley 2000).

The algebraic approach frees one from a simplistic attribute-value based representation of TMAD systems which tends to treat interdependent categories like tense and mood as orthogonal features and therefore is at pains to explain why the features do not combine freely. In the algebraic approach, we are free to vary the combinatorics and search for the most efficient solution.

In these terms, Guillaume’s drawing can be translated into the following regular expression:

(ind(past|pres|fut) | sub(past|pres)) | inf(simple|perf)

The last term of the expression represents the vertical dimension of Guillaume’s drawing. The first term represents the horizontal dimension. The alternation inside the first term represents the depth dimension. The above regular expression generates the language.
The regular expression representation gives a handle on looking for typological comparisons and generalisations in terms of regular expression equivalences.

One can also compare alternative representations of the same set of forms. Given the equivalences, there is no obligation to think that any one of the alternatives is the only correct one. Consider for instance the following version, which generates the same set of forms for Latin.

\[
\text{(fin((ind | sub)(past | pres) | fut) | inf)(simple | perf)}
\]

This version treats future on a par with moods. Assuming that \text{ind}, \text{pres}, \text{inf}, and \text{simple} are the unmarked forms of mood, tense, person, and phase, respectively, i.e. denote identity, then the above formula simplifies to

\[
\text{(fin (sub?past? | fut))? perf?}
\]

This representation suggests that the Latin TMA system is a two-tense system at heart, despite the apparent tense symmetry in the indicative.

For classical Greek finite forms, the following expression is one of many possibilities.

\[
\text{(opt|sub|past)?(pf|perf)? | opt?fut}
\]

This enumerates a 4 by 3 matrix of four inflections by three stems, plus future for two moods. The treatment of past tense on a par with the moods may look curious, but it produces the shortest regexp so far. Come to think of it, the past tense is indeed what characterizes indicative mood in complementary distribution with moods proper (Guillaume 19??:§55,69). Note too that the three Greek past tenses share a morphological exponent, a past tense prefix (the augment). If we further accept the idea that optative and subjunctive are related as past and present of a bound future mood \text{bf}, we get

\[
\text{(bf?past?(pf|perf)? | (bf.past)?fut}
\]

where e.g. \text{bf.past.pf} represents the aorist optative \text{(eithe) nikesaimi} ‘I wish I’d win’. The future optative \text{bf.past.fut} \text{(ephe hoti) nikesoimi} ‘he said I’d win’ is only used for bound past future in past \text{oratio obliqua} (Kühner 1898:183).

The above parallelism of mood and past tense gives a new slant to the generalisation that there are more tenses in the indicative than in other moods. One might instead say that simple past is the exponent of indicative mood.

The English tense system can be analogously described as the regular expression \text{past? will? have?} which produces eight forms (Declerck 1997:63). Taking moods and aspects along, the tally goes up, e.g. \text{past? will? have? ing?} gives 16 form. Counting modals (\text{may, must, etc.}) or near tenses like \text{be going to} raises the number higher. What about temporal adverbs like \text{just or already}? It is hard to decide where to stop. One is tempted to ask who cares.

\textbf{Deictic shift}

Declerck (1997) divides up English time first into \text{past} and \text{present} and present further to \text{pre-present, now, and post-present}. By her count, English has four \text{absolute} tenses which relate event time directly to (her) temporal divisions. They are simple past, present perfect, present, and future \text{will}. Declerck’s way of looking at English is also a valid one by the calculus. The first clause spells out Declerck’s division of time. It is important to note that the division is not a
partition. The same event can be described as belonging to the past and to the pre-present (I met Ann just now and I have just met Ann). The second clause is the insight about extended now. The third clause is the enumeration of the absolute tenses as a regular expression.

\[
1 = \text{in past } \cup \text{ <now< = in past } \cup \text{ <now } \cup \text{ now } \cup \text{ now<}
\]

\[
\text{now } = \text{perf } \cup \text{ pres } \cup \text{ fut } = \text{perf.pres.fut}
\]

\[
1 = \text{pret } | \text{(pres|perf|fut)}
\]

All of these event types are valid in the calculus.

This formalisation of Declerck’s approach also formalises deictic shift, or the notion of a shift of an entire deictic frame forward or backward (Duchan et al. 1995). For instance, backward and forward shifted tenses can be calculated from the equations:

\[
\text{pret 1} = \text{pret (pret | (pres|perf|fut) = pret pret | pret (pres|perf|fut) = pret pret | pret pres | pret perf | pret fut}
\]

\[
\text{fut 1} = \text{fut (pret | (pres|perf|fut) = fut pret | fut (pres|perf|fut) = fut pret | fut pres | fut perf | fut fut}
\]

This gets us four shifted tenses in the past and another four in the future. Not only that, but it also generates the combinatorics of the shifted tenses described in Declerck (1997:§4) in one go.

**Typology of TMAD systems**

Looking back at what we have found so far, TMAD systems have been considered at least along the following dimensions: If each dimension makes as much as one independent two-way distinction, there will be anywhere between a thousand and a million combinations. Only a few combinations make sense, fortunately, which shows that the distinctions are far from independent in the intended models of natural language.

- Diathesis
- Aktionsart
- Aspect
- Free/bound tense
- Genericity
- Definiteness
- Quantification
- Modality
- Free/bound mood
- Subordination
- Discourse type

**Dahl-Bybee method**

Dahl (1985:154ff) surveys a number of TMA systems around the globe. It does not address the paradigm/completeness problem, but singles out prototypical patterns of tenses and aspects. The methodology in questionnaire surveys like Dahl (1985) or the EUROTYPO project start from the meaning end, comparing how languages express various event types. An empirical study of markedness was made in the typological survey by Dahl (1985) (Myhill 1992). His 200 item questionnaire translated into 64 languages surveys a part of the semantic space tense and aspect forms have to cover. Dahl’s study has been accused of an Indo-European bias in the selection of languages and the prototypes it tries to establish. (Plu)perfect and (im)perfective may be characteristically Indo-European categories (Myhill 1992:98). Nevertheless, I would be surprised if the distinctions they are based on were found entirely absent in other languages, rather than grouped and expressed in other ways.\(^{272}\)

One difficulty in evaluating Dahl’s data is that the lexical aspect of the input is not known. One cannot tell whether an aspect form is marked without knowing what it applies to. The translation relation is not tight enough for that. At any rate we can check if Dahl’s prototypes correspond to the schematic meanings given here.

\(^{272}\)Hopi was claimed by Whorf to have no tenses, whereas in reality, the main oddity about Hopi is that it has a future-nonfuture tense distinction instead of the more familiar past-nonpast one. Within nonfuture, the present-past distinction is replaced by a perfective-imperfective aspect distinction, making Hopi a sort of mirror image of Russian (Malötki 1983: Ch.9.4.) Inuktitut (Eskimo) has been claimed to have no tense in the sense of an obligatory inflection on the verb but it does express time. The unmarked form of a verb is nonfuture. (Nowak 1994).
Dahl’s core instances of the perfect are covered by the present perfect by our definition. The number in the parentheses is the number of languages which have a form subsequently classed as a perfect by Dahl’s voting technique.

A: I want to give your brother a book to read, but I don’t know which. Is there any of these books that he READ already?
B: Yes, he READ (31) this book.
    perf pf read (he does not want to read the same book again)
A: It seems that your brother never finishes books.
B: That is not quite true. He READ (28) this book (= all of it).
    perf pf read (he has finished this book)
Q: Is the King still alive?
A: No, he DIE (28).
    perf die (he is dead)
Q: You MEET (27) my brother (at any time in your life until now)?
    perf become know or perf meet once.
Getitng to know someone and meeting them may be different verbs in different languages.

CHILD: Can I go now?
MOTHER: You BRUSH (27) your teeth?
    perf brush or pf brush
English allows simple past if there was a definite time to brush.

The following (numbered) verbs in are Dahl’s core candidates for past perfective. They are all definite pasts of a closed event type.

Do you know what happened to me yesterday? I WALK in the forest. Suddenly I STEP (31) on a snake. It BITE me in the leg. I TAKE a stone and THROW it at the snake. It DIE (32).
    pf step, pf die. These are unmarked perfectives assuming step is a change or cycle. Note that the prototypical perfectives occur at the beginning and end of the narrative.
Q: What was your brother’s reaction to the medicine yesterday?
He COUGH once (32)/twice (31). Coughing once or twice are both closed, coughing once is a cycle. The time reference is definite.
Q: How long did it take for your brother to finish the letter?
A: He WRITE (31) the letter in an hour.
    pf write in hour. Time limited event is closed.

The progressive was quite common, occurring in 27 of the 64 languages in Dahl’s sample. It is not Indo-European specific. The pluperfect prototype was found in one third of the languages surveyed, most of them Indo-European. This is not surprising if pluperfect arises as a bound past of perfect aspect. A language having a pluperfect is predicted to have a simple past tense and bound, dependent tenses in addition to free, indexical tenses. It need not have a present perfect, however. Other non-eurocentric categories that turned up in Dahl’s study were dubbed experiential perfect (8 languages), habitual (8), past habitual (5) and quotative (6).

An impressive instance of the Bybee/Dahl methodology combining questionnaire and reference grammar evidence for wide-coverage empirical typology is Dahl (1998), reporting the results of Theme Group 6 of the EUROTYPE project on tense and aspect systems.

**Cohen 1989**

Cohen (1989) presents an elegant typology based on historical as well as comparative evidence. For Cohen (1989) the active core of aspect systems is a fourfield of open/closed vs. simple/complex aspect:
Compound aspects mark a reference time concomitant (simultaneous or adjacent) with event time. This fourfold allows distinguishing the four commonest aspects: perfective and imperfective (simple closed and open), progressive and perfect (compound open and closed). Composition forms new progressives and perfects, imperfectives and perfectives get grammaticalised and eventually pushed as simple base forms into marginal roles (Bybee 1994). Old imperfectives become subjunctive, modal or generic while old perfectives become subjunctive, sequential narrative or gnomic forms. A prototype of such waves of innovation is the following one from Aramaic (Cohen 1989:151). The diagram represents a typical succession of systems of open aspect. New waves flush in right to left. In old Aramaic, there is just one imperfective form. In Middle Aramaic, a new progressive based on a present participle has come in. This progressive then becomes the unmarked imperfective, marginalising the old imperfective. In New Aramaic, a second new progressive gets formed, creating a three-term system. In dialects, the old imperfective has dropped out, and a third progressive starts a new cycle.

\[
\begin{array}{ccc}
\text{marginal} & \text{neutral} & \text{marked} \\
\text{Old} & yi-qtul & \\
\text{Early Mid} & yiqtul & qâtil \\
\text{Late Mid} & yiqtul & qâtil \\
\text{New} & yiqtul & qâtil & ki-qâtil \\
\text{Dial.} & qâtil & ki-qâtil \\
\text{Dial.} & qâtil & ki-qâtil & bi-qtâla-île \\
\end{array}
\]

Table 94

Raible (1990) presents a purely deductive taxonomy of types of tense and aspect systems based on the features tense vs. aspect system, pure vs. mixed system, marked or unmarked lexical aspect, and unmarked perfective vs. imperfective:

1 pure system
   1a pure aspect system
      1aa lexical aspect marked
         1aaa perfective unmarked
         1aab imperfective unmarked
      1ab lexical aspect unmarked
         1aba perfective unmarked
         1abb imperfective unmarked
   1b pure tense system
2 mixed system

This is not bad, in particular if we can enumerate the ways in which tense and aspect are marked in each type of system. The impression is that there is only a limited number of possible sources for exponents for tense and aspect, and the choice influences the type of system that can arise.
More generally, a descriptive typology of aspect systems can be formed from the event types which get grammatically marked cross-classified according to the grammar of the marking: lexical (suppletive or derivational), or grammatical (inflectional or phrasal). Finnish object marking is a half-closed/open inflectional system. Russian is predominantly a (half)-closed derivational system. English has a phrasal progressive-perfect system. French has a grammatical closed-open system in the past. But such labels are only approximations of a point by point comparison of the entire event type maps of the languages.

Cohen (1989) pits the lexically marked Slavic aspect (1aab) as the odd one out typologically, against Semitic aspect (1aba) which represents a commoner case.

**Thieroff 1994**

Thieroff (1994) categorises individual tense, mood, and aspect forms cross-linguistically with decision trees and tables where he tries to fit the tenses of various European languages. It is not always clear whether his categories are semantical or morphological (or both), for instance, where the contrast between single and double perfect forms (the ‘temps surcomposés’of spoken French and German) should go. For another example, Russian is said not to have a subjunctive because the Russian subjunctive marker is a free particle. There is arbitrariness also in the hierarchical ordering of distinctions (typical of decision trees).

Thieroff’s category table is the following. Thieroff’s distinction (non)remote is not a remote/near tense distinction as defined here (or in Comrie 1976), but rather a (non)past distinction: Thieroff (following Lyons 1977) is using remoteness as a cover term for past and counterfactual events (cf. section on counterfactuals). With this proviso, Thieroff’s Reichenbachian definitions of his tenses suggest the translations given in the table.

<table>
<thead>
<tr>
<th>indicative/subjunctive</th>
<th>non-remote</th>
<th>remote</th>
</tr>
</thead>
<tbody>
<tr>
<td>now&lt;e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e≤now</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e≤now</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-posterior</td>
<td>posterior</td>
<td></td>
</tr>
<tr>
<td>posterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-posterior</td>
<td>posterior</td>
<td></td>
</tr>
<tr>
<td>posterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>e&lt;now</td>
<td>Future</td>
<td></td>
</tr>
<tr>
<td>e&lt;now</td>
<td>Preterit</td>
<td></td>
</tr>
<tr>
<td>non-posterior</td>
<td>posterior</td>
<td></td>
</tr>
<tr>
<td>posterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e`r</td>
<td>Perfect</td>
<td></td>
</tr>
<tr>
<td>e`r&lt;now</td>
<td>Future perfect</td>
<td></td>
</tr>
<tr>
<td>e`r&lt;now</td>
<td>Pluperfect</td>
<td></td>
</tr>
<tr>
<td>anterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e`r</td>
<td>Past future</td>
<td></td>
</tr>
<tr>
<td>e`r&gt;then&lt;now</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 95

Given a box to fill, there is a temptation to find something to fill it, however marginal it may be in the language. Fitting different languages in a fixed categorial grid emphasises similarities in paradigms but conceals differences in the meaning and distribution of forms. The tabulated forms do not form equally tight paradigms in the different languages. For instance, the Finnish past *tuli tekemään* of the future periphrasis *tulla tekemään* ‘be bound to do’ listed in the past future box for Finnish by Thieroff (1994:15) is not a bound past future ‘would do’, but (at best) a free past future ‘subsequently did’. The typical jobs of a past future (counterfactual conditionals and indirect speech) are done by the conditional *tulisi* in Finnish. Whether Finnish ‘has’ a future perfect *tulla olemaan tehnyt* is a moot question. Noting the past/nonpast tense morphology of the conditional and potential moods in Finnish, Thieroff (1994:14) suggests that the two moods be construed as the past and nonpast tenses of a subjunctive mood. Semantically, this solution misrepresents both present day Finnish and the cross-linguistic category of subjunctive. The Finnish potential is a free nonpast epistemic mood glossed by *probably*. It is practically extinct from spoken Finnish.273. Another result paradoxical for Finnish which has no future gram is that Thieroff (1994:42) finds future the only category common to all the languages surveyed.

**Evolutionary typology of TMAD systems**

How should one describe and compare TMAD systems (as opposed to individual grams)? The idea of a transition map or chart enumerating attested paths of development between TMAD forms seems useful. The arcs of the chart are labeled by the morphological and semantic processes of grammaticalisation involved in the change. The chart can be enumerated as a list of triples <start state, transition, end state>. It would help to dimensionalise the chart by enumerating possible types of change ahead of time.

273*Perhaps, probably, and certainly are the epistemic modalities representing the generalised quantifiers some, most, and all.*
A similar chart of possible transitions between TMAD systems is the next order, emulating the advance of evolutionary study from species into populations and ecological communities.
<table>
<thead>
<tr>
<th>Old form</th>
<th>Change</th>
<th>New form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (go/come) to</td>
<td>space-time metaphor</td>
<td>(near) future</td>
<td>many</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Anderson 1973, Givón 1973)</td>
</tr>
<tr>
<td>P (go) from</td>
<td>space-time metaphor</td>
<td>(near) past</td>
<td>gaelic, basque, tibetan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Anderson 1973)</td>
</tr>
<tr>
<td>P (go) through</td>
<td>space-time metaphor</td>
<td>past perfective</td>
<td></td>
</tr>
<tr>
<td>P (be) in state/activity</td>
<td>space-time metaphor</td>
<td>interior progressive</td>
<td>many</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Traugott 1973)</td>
</tr>
<tr>
<td>P (be, stay) at</td>
<td>space-time metaphor</td>
<td>neighborhood progressive</td>
<td>many (en, fi, de, sv, is)</td>
</tr>
<tr>
<td>P (stay) at</td>
<td>space-time metaphor</td>
<td>result state perfect</td>
<td>chinese</td>
</tr>
<tr>
<td>P (be) after</td>
<td>grammaticalisation</td>
<td>near perfect</td>
<td>gaelic</td>
</tr>
<tr>
<td>P here, there (is)</td>
<td>grammaticalisation</td>
<td>future tense</td>
<td>korean kess, berber ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Ultan 1978)</td>
</tr>
<tr>
<td>A temporal adverb</td>
<td>grammaticalisation (affixation)</td>
<td>tense</td>
<td>tok pisin nau</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Traugott 1978)</td>
</tr>
<tr>
<td>A here, now</td>
<td>grammaticalisation</td>
<td>present tense, progressive aspect</td>
<td>fula do</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Cohen 1989)</td>
</tr>
<tr>
<td>A by now, already</td>
<td>grammaticalisation</td>
<td>near perfect</td>
<td>chinese le, pt já, ru uzhe, arabic qad, fula do</td>
</tr>
<tr>
<td>A result adverb</td>
<td>grammaticalisation</td>
<td>perfective</td>
<td>slavic, margi</td>
</tr>
<tr>
<td></td>
<td>abstraction</td>
<td></td>
<td>(Dahl 1984)</td>
</tr>
<tr>
<td>A) number/frequency adverb</td>
<td>affixation of adverb</td>
<td>frequentative derivational aspect</td>
<td>slavic</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------</td>
<td>---------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>A) ready, finished</td>
<td>grammaticalisation</td>
<td>perfective perfect</td>
<td>many (Traugott 1973)</td>
</tr>
<tr>
<td>A) inflected active past participle</td>
<td>grammaticalisation as finite complement</td>
<td>active perfect</td>
<td>de, fi, bulgarian</td>
</tr>
<tr>
<td>A) inflected passive past participle</td>
<td>grammaticalisation as finite complement</td>
<td>passive perfect</td>
<td>en, gr</td>
</tr>
<tr>
<td>A) uninflected gerund (deverbal adverb)</td>
<td>grammaticalisation as finite complement</td>
<td>progressive</td>
<td>es, pt</td>
</tr>
<tr>
<td>A) inflected active present participle</td>
<td>grammaticalisation</td>
<td>progressive</td>
<td></td>
</tr>
<tr>
<td>V) finite auxiliary</td>
<td>loss of inflection</td>
<td>temporal adverb or tense</td>
<td>arabic nābārā, allo, creole bin, te</td>
</tr>
<tr>
<td>V) present perfect</td>
<td>reference time shifts to event time</td>
<td>simple past perfective</td>
<td>many, e.g. latin, de, fr ongoing</td>
</tr>
<tr>
<td>V) present perfect</td>
<td>indefinite to de dicto</td>
<td>evidential</td>
<td>turkish mis</td>
</tr>
<tr>
<td>V) simple past perfective</td>
<td>loss of indexical time reference</td>
<td>simple perfective</td>
<td></td>
</tr>
<tr>
<td>V) simple past perfective</td>
<td>loss of aspect</td>
<td>simple past</td>
<td></td>
</tr>
<tr>
<td>V) past perfect</td>
<td>loss of reference time</td>
<td>remote past</td>
<td></td>
</tr>
<tr>
<td>V) frequentative derivational aspect</td>
<td>grammaticalisation of affix</td>
<td>imperfective grammatical aspect</td>
<td></td>
</tr>
<tr>
<td>V) motion causative</td>
<td>space-time metaphor</td>
<td>phasal verb</td>
<td></td>
</tr>
<tr>
<td>V) phasal verb</td>
<td>affixation</td>
<td>aspect</td>
<td>Altaic</td>
</tr>
</tbody>
</table>
Table 96

The transition chart reveals frequent sources and sinks (Johanson 1998), and raises the question why just these sources and clines are active, and what drives them. Why do languages need new progressives, near futures and perfects?

The logic of grammaticalisation

Grammaticalisation involves abstraction of meaning related to a corresponding cline of morphological reductions. New aspects start out as compositions of lexical diathesis.

Formally, grammaticalisation may not look like simplification of event types. Compare perfects e\now or e`now to simple past e<now or progressive in p of e to imperfective gen pf* e. However, the changes are disjunctive, so the overall trend is toward weaker forms. Weak, loose and generic event types are abstracted from strong, tight and specific event types. In general, grammaticalisation widens the domain in which the gram is defined, and abstracts the mapping it defines. What grammaticalisation does to lexical aspect is detach it from lexical event types so as to let it commute with other operators of the event calculus.

Children learn present first and present perfect before simple past (Johanson 1998). Grammaticalisation of tense and aspect moves away from the here and now: it extends the scale and coarsens the resolution of the event types (Comrie 1976:61, Johanson 1998:§8.10.2). Johanson (1998:§7.4) observes that new progressives appear first in nonpast tenses. The process of abstraction seems to begin in past tenses, where perspective is longer (Johanson 1998:§7.8).

Change in resolution turns connected event types to their weak duals. Due to vagueness of scale, there is no way to ensure (for long) that right now means 'as I speak'. Similar comments apply to perfect and future: they develop from diathesis into near aspects and become remote tenses with time. A law of procrastination rules: I'm on it promises I may do something about it eventually. Fresh ways of indicating immediacy keep arising with new generations, fashions and dogmas (Johanson 1998:§8.10). Pressure from below appears necessary for a gram to shift to new duties (Johanson 1998:§8.10.2, §11.6). Breeding grounds can be found in aspectual competitions where existing forms are too vague to make a crucial distinction.

There have been many attempts at grouping and labeling facets of the process of grammaticalisation. Here are some of the central notions (Dahl 1998), Bybee (1999), Johanson (1998):

- Abstraction. Lexical content is lost.
- Defocalisation. Focus shifts from near to remote.
- Contextualisation. Content becomes a function of context.
- Generalisation. Lexically governed form is generalised to a larger class of event types.
- Automatisation. Form becomes redundant or obligatory.

Examples of contextualisation are development of finite forms out of infinitivals, weakening of result perfect to current relevance perfect and the development of finite perfectives out of closed event types.

The notions are obviously interdependent. Defocalisation and contextualisation are abstractions, and generalisation and redundancy follow from it. The challenge is to find an axiomatics to the process analogous to the systematics of (related) concepts in the mathematical theory of information and systems theory (Shannon/Weaver 1949, Ashby 1959). This is also where fashionable analogies between biological evolution and the evolution of grammatical systems (Dahl MS, Haspelmath MS) have a common denominator.

Evolution in other systems can provide analogies, perhaps even testable theories. Why is nature cyclic? Why do animals get born and die? Why do species die and come about? Because there are both cyclic and catastrophic changes in their environment. Language is spoken by people who learn it from scratch, negotiate with others using it, pass some of it to the next generation, and take some of it with them when they die. Language communities do the same on a higher level of organisation. Though compelling, this model is still at a trivial qualitative phase in linguistics. As the example of evolution theory and ecology shows, it can become more exact and predictive when worked out in quantifiable detail.

Lexical classification

An average natural language may have a few thousand verb entries in its dictionary. It is not an impossible task to collect them in a dictionary (it has been done). With enough resources, it is possible even to write formal analyses for a few thousand entries (witness the Wordnet or EU Parole projects, for instance). The main problem is what to write under each entry.
There is no consensus or standard about what facts belong to a verb entry, and how they should be notated. It is not even an objective issue. If the meaning of words is largely contextual, how large a slice of that context should be included in verb entries?

Even less is there a standard for annotating facts about verbs, whatever the facts are. There are traditional tags, even some attempts to standardise their meanings (for instance, EAGLES). However, the study made in this work for instance makes it clear that a simple tag like transitive is not very reliable.

There is the problem about word senses. How many senses for a given word are there, and how are they individuated? How to capture what is common between word senses and what is different? There is a host of schemes for reducing redundancy in lexical entries based on inheritance one way or another.

In this chapter, I consider what help the calculus developed might provide for lexical classification.

**Lexical classification with event types**

As concerns the borderline between lexical system and its environment, there is not much to say. I provide no criterion to distinguish between absolute and contextual meaning here. On the contrary, much of what I say indicates that the field is inherently fluid.

As concerns how information should be coded, it is in the nature of a calculus that there is no unique normal form. In recompense, there is a lot of logic to move between different notational variants.

It is also in the nature of a calculus that there is no unique way of splitting information. My calculus is not a hierarchy, it is a network of morphisms. If word classification implies a tree structure, the calculus supports many choices.

Since the calculus is closed under Booleans, one verb can inherit from more than one by satisfying their meet, or be vague between them by satisfying their join. An ambiguous event type is a Boolean sum.

In the body of the work, many common event types have been given one or more notations. These notations, or concise shorthands for them, can be used to name verb classes and tag verbs with them. A tag on a verb indicates that the verb is a subtype of that event type.

If concrete syntax could be carried through for compositional morphology and grammar, only lexicalised meanings would need tagging. The types of compositional derivatives could be calculated from their morphological makeup.

This also generalises to the lexicon. Lexical entries can then be defined in terms of one another, for they name event types too. Given enough concrete syntax, English words could be described in a kind of sense indexed Basic English. (This is of course already entirely fabulous.)

The definition of a complex event type can be quite long, like the definition of a game, which is a summary of game theory. But it is not necessary to have explicit definitions, event types can also be characterised by postulates (Boolean inclusions).

This model of classification supports parceling out partial information about verbs and allows redundancy. Given closure under Booleans, aspect type can be derived from diathesis or given as a separate tag. The consistency of the tags can be tested using the calculus.

Default inheritance DATR style is supported through Boolean priority operations.

**Lexical classifications**

Genusiene (1987:36) has this classification:

1. stative verbs denoting states
2. actional verbs denoting actions and motion
3. inchoative verbs of process denoting a change of state
4. causative verbs denoting causation of a state or process
5. causative verbs denoting causation of an action

**Example grammar**

[Here might be a small English dictionary and grammar based on the calculus. Everything is defined as event types: constructions, words, morphemes, features, you name it. ]

**Retrospect**

van Benthem’s logical typology of tense and aspect is a rational reconstruction of the logic of time first registered in a theoretical way by the classics and summed up in Aristotle’s metaphysics. The first layer, subject to the laws of Quality
and Continuity, generate the Priorian trichotomy of tense into past, present, and future based on temporal order, the domain of the fourteen Priorian tenses and the adverbs since and until of Kamp’s theorem. Weakening the law of Continuity to Bounded Continuity, we obtain aspect, the topological distinctions between beginning, middle, and end, connected and disconnected, interior and boundary, and adjacent (near) vs separated (remote) tense.

Weakening or restricting the law of Quality allows indexical now and then and brings in anaphoric and metric tenses and adverbs: was vs. has been, second, minute and hour, today, yesterday and tomorrow. Modality, causality and agency bring in yet a finer level of detail, allowing to distinguish between post hoc and propter hoc, between may, must, and will, between happening, causing, and doing.

The referential distinctions of the Parmenidean one vs. many: particular vs. general, singular vs. plural, concrete vs. abstract, specific vs. generic, definite vs. indefinite run across the domains, reflected in the mathematics of the discrete and the continuous, the integers and the real line, algebra and geometry, meeting dually in set theory and Boolean algebra (Stone representation theorem).

Duality runs through all of semantics: it is the duality of language and world, intension and extension, theory and its models, situations and possible worlds, partial functions and sets of total ones. Semantics thus turns out to be largely an application of Boolean algebra (Keenan and Faltz 1985). However, as van Benthem (1986:214) puts it, one may use any respectable formal method, particularly provided that translations exist relating the different perspectives.

**Basic distinctions**

This essay has gradually developed a theory of many of the most fundamental aspect distinctions or features. These distinctions have turned out to be special cases of a few central referential distinctions in natural language which have been recognised at least since the classics. Their close interconnections tend to blur the distinctions together and explains why there is so much disagreement about which distinction is the crucial one for aspect. They all are.

The first one is a key notion of Aristotle’s metaphysics, the Parmenidean distinction between one and many, better known now as the count/noncount distinction. This distinction is based on identity criteria which determine which regions in the multidimensional space of reality are the same and which different. The main bifurcation here is between noncount and count reference, reflected in the distinction of atomless and atomic Boolean algebra (set theory). It generates the basic trichotomy between quantities, individuals, and pluralities.

In the temporal domain, it appears as the duality of open/closed events, characterised by closure under joins or meets. It is the source of the distinction between perfective and imperfective aspect which distinguishes individual events from durative and iterative ones. A core notion is atomary (singular closed i.e. simply closed, closed and connected) atomary event:

**Atom:** $b + b \cap b = \emptyset$

**Closed:** $e = \cap e$

I have also proposed how the closedness distinction can be given a topological interpretation in terms of open and closed sets to create the intuition of perspectival aspect (a pointlike event embedded within the context of an extended open background).

A related fundamental distinction is the distinction between whole and part, or total (universal) and partial (existential) reference. This can be defined in Boolean terms as the distinction between the (trivial Boolean algebra of) the unit element $\mathbb{U}e$ of a Boolean algebra $e$ and the algebra $e$ itself. Reference is total where they coincide and partial otherwise.

**Total:** $e = \mathbb{U}e$

A special case of the total-partial distinction is the distinction between definite and indefinite reference which arises when the count-noncount distinction is intersected with the total-partial distinction. Definiteness for individual reference can be defined in Russelian terms as contextual uniqueness (maximality or totality in the singular). A reference to an individual is definite if there is precisely one individual of the type in the context. I have discussed how the definite-indefinite distinction relates to closure and perfectivity. Another notion of Boolean order the notion of generic reference (whether a property characterises a kind as a whole, in part, or for the most part).

The third traditional aspectual notion is resultativity or telicity which involves the causal or counterfactual structure of events. A telic event is half closed, one which ceteris paribus entails a change. Ceteris paribus relates telicity to causative diathesis.

**Telic:** $\sigma \rightarrow \neg \gamma.r.r$

Tense draws its central notions from the intertwined domains of time and modality and in particular temporal order. For temporal order, I have chosen among many alternative formalisations, an algebraic representation in terms of
concatenation algebra. This representation is in itself neutral about the relation of time and modality, but the branching future model is in many ways a useful one for natural language.

The interplay of generic reference (partial-total distinction) with time and modality gives rise to temporal quantification and **generic** (habitual-dispositional) aspect. The theory of contextual (counterfactual) conditionals in turn serves as a bridge from the notions of time and modality to **causation**.

Returning to Jespersen’s grid, we might now formalise it as follows:

<table>
<thead>
<tr>
<th>Greek</th>
<th>Latin</th>
<th>French</th>
<th>English</th>
<th>German</th>
</tr>
</thead>
<tbody>
<tr>
<td>perfect</td>
<td>ge graphe</td>
<td>scripsit</td>
<td>a écrit</td>
<td>has written</td>
</tr>
<tr>
<td>perfective</td>
<td>pf e&lt;now</td>
<td>pf e&lt;now</td>
<td>e’ now</td>
<td>pf e&lt;now</td>
</tr>
<tr>
<td>generic</td>
<td>e graphe</td>
<td>scripsit</td>
<td>ecrivit</td>
<td>wrote</td>
</tr>
<tr>
<td>progressive</td>
<td>ipf e&lt;now</td>
<td>ipf e&lt;now</td>
<td>ipf e&lt;now</td>
<td>wrote</td>
</tr>
</tbody>
</table>

**Table 97**

As a formalisation, the result does not look all that impressive. What impresses me more is the relative simplicity, even beauty, of the mathematics behind it all: that natural language tense, mood, aspect and diathesis in all their complexity are not endlessly complicated after all.

“Any real exception (from a regularity) causes surprise as such by itself, but this surprise is nothing in comparison with the astonishment which is aroused by the uniform organization of the majority of languages since this uniformity is not logically necessary” (Zhivov/Uspenskij 1981:25, quoted in Genusiene 1987:307, italics mine). I agree with the sentiment, but not with the cause. My research is converging toward a conviction that uniformity in natural language is due to logical necessity much more often than meets the eye. (van Benthem 1986:).

**New prospects**

One of the driving forces of change is the erosion of both forms and meanings in language use. The latter is known in historical linguistics and evolutionary typology as semantic **bleaching**. The idea of bleaching gets more structure with a formal semantics. Formalisation helps specify just what colors are lost in the bleaching: which components of a spectrum of meanings are lost and which preserved, what developmental paths there are in principle, and perhaps even what changes are more likely a priori than others, given suitable distance measures between meanings.

Mechanisms of bleaching as well as enrichment of meaning are metonymy and metaphor. Metonymy is involved in the shifts of semantic labor that take place at loci of neutralisation. Metaphor is involved in the abstraction of meaning under structure preserving mappings between different domains of discourse.

The causes of change are another matter. Dahl (2000) looks at model explanations from evolutionary biology. In his opinion, the most fruitful comparison is not so much the law of the survival of the fittest, but rather the law of succession of generations that follows from degeneration with age. I think both laws are needed, and a third one should be added, and that is periodic variety in the environment. Language is renewed at generation shifts much the way forests are renewed after a forest fire. New language learners (children or immigrants) introduce pioneering forms whose competitive advantage is regularity and versatility rather than precision or elegance. When the competition hardens, as the game of life approaches a zero sum equilibrium, less adaptable, but more specialised forms win out.

The interest of the biological analogy depends in the last analysis on whether the mathematical models developed for biological evolution find application to language change. Or so I think.

**Appendices**

**Appendix 1: Who uses which idea?**

Similar ideas about tense, aspect, mood and diathesis have been invented, inherited and reinvented many times over. Here is a very partial enumeration.

**Event calculus**

- Kotarbinski 19??, v Wright 1963,
Aspect shifts

Resolution: granularity, scale,

Grammatical complements contribute to aspect

Count-noncount/perfective-imperfective

Aspect is compositional

Aspect is deictic or perspectival

Aspect is different from Aktionsart

Two-level aspect

Progressive/imperfective inside an event
Montague 1968, Scott 1970, Bennett/Partee 1972, Dowty 1979,

Progressive is temporary

Perfective looks at event from outside
Kamp 1979, Kamp/Rohrer 1983
<table>
<thead>
<tr>
<th>Topic</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfective events pointlike, imperfective extended</td>
<td>Kamp 1979, Eberle/Kasper 1994</td>
</tr>
<tr>
<td>Extended events have parts, points are atomic</td>
<td>Aristotle, Wiener 1914, Kamp 1979</td>
</tr>
<tr>
<td>Prototypes vs. schemas</td>
<td>Timberlake 1982, Dahl 1985, Langacker 1987</td>
</tr>
<tr>
<td>Achievements/activities</td>
<td>Aristotle <em>Met</em>. 1048, Ryle 1949:149, Kenny 1963:</td>
</tr>
<tr>
<td>Accomplishments/achievements</td>
<td>Ryle 1949, Vendler 1957</td>
</tr>
<tr>
<td>Activities/states</td>
<td>Kenny 1963, Vendler 1957, Lakoff 1965</td>
</tr>
<tr>
<td>Atomarity (indivisibility, nonadditivity) of closed event types</td>
<td>Taylor 1977, Krifka 1987, 1989, Cooper 1986</td>
</tr>
<tr>
<td>Existential perfect</td>
<td>Inoue 1979, Abusch/Rooth 1990</td>
</tr>
<tr>
<td>Priorian tense logic</td>
<td>Prior 1967, Montague 19??</td>
</tr>
</tbody>
</table>
Many-dimensional tense logic

Reichenbachian tenses
Reichenbach 1947, Comrie 1985, Lindstedt 1985

Tenses as variables/anaphors

Tense as agreement with adverbs

Tense as proximal vs. distal deixis

Sequence of tense is agreement
Ladusaw 1977, Comrie 1985, Kamp/Rohrer 1983

Sequence of tense is binding

Sequence of tense is deictic shift

Simple past is definite and perfect indefinite

Narrative progression is a semantic rule

Narrative progression is a discourse strategy

Now/present varies in granularity

Cause-become decomposition
Pustejovsky 1995

Diathesis changes information structure (topic-/focus-background distinctions)
Appendix 2: Who calls what what?
Like the rest of linguistics, TMA literature is a terminological thicket (Andersson 1972, Maslov 1978, Dahl 1981, Guentcheva 1990). Here is a section of the thicket. The terminological fit is bound to be fuzzy, especially as concerns the tricky closed-resultative distinction

<table>
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<th>Event type</th>
<th>Compare</th>
<th>Author</th>
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<td>Aspectual class</td>
<td>Dowty 1979:53</td>
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<td></td>
<td>Aktionsart</td>
<td>Platzack 1979, Raible 1990,</td>
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<td></td>
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<td>Bartsch 1995</td>
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<td>Actionality</td>
<td>Csató 1994, Bertinetto/Delfitto</td>
<td>1998, Johanson 1998,</td>
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<td></td>
<td>Event notion</td>
<td>Schopf 1981, Hamann 1989</td>
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<td></td>
<td>Notional aspect</td>
<td>Bybee et al. 1994:85</td>
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<td></td>
<td>Inherent aspect</td>
<td>Comrie 1976, Chung/Timberlake</td>
<td>1985</td>
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<td>Character of action</td>
<td>Goodwin 18??, Poutsma 1921</td>
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<td>Aspectual character</td>
<td>Lyons 1977, Galton 1984,</td>
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<td>Lindstedt 1985</td>
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<td>Temporal</td>
<td>François 1985</td>
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<td>Situation type shift</td>
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<td>Moens 1987, Santos 1996</td>
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<td>Forsyth 1970</td>
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<td>Mode of action</td>
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<td>State of affairs</td>
<td>Lapolla/Van Valin 1997:83</td>
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<td>Galton 1984:25</td>
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<td>Bybee et al 1994</td>
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- **Semelfactive**: Smith 1991
- **Happening**: Bach 1986
- **Quantified process**: Schopf 1984
- **Intergressive**: Löbner 1988
- **Pofective**: Galton 1984, Herweg 1991
- **Holistic state**: Partee 1984
- **Action**: Steedman 1977
- **Multiple event**: Smith 1991
- **Sentential aspect**: Chung/Timberlake 1985
- **Viewpoint aspect**: Smith 1991
- **Aspectual form**: Dowty 1979:53
- **Viewpoint operator**: Johanson 1998
- **Adterminal**: Johanson 1998
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**Perfective**

**Imperfective**

**Progressive**
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Appendix 3: Who refers to whom?
Dowty 1979
Raible 1990
Nowakowska 1973
Nerbonne 1986
Vlach 1993
Hamann 1989
Löbner 1988
Herweg 1991
Huddleston 1969
Hirtle 1975
Verkuyl 1993
Csató 1994
Johanson 1998
Portner 1998
Panitz 1998
Heger 1967, Bühler 1934
Kotarbinski 19??
Reichenbach 1947, Dowty 1982
Davidson 1967, Parsons, Partee 1984, Dowty 1979, Bach 1983
Schopf 1984
Galton 1984
Löbner 1988, Galton 1984
Halliday 1967
Guillaume 1929, Valin 1965
Gruber 1976, Jackendoff 1990
Johanson 1971
Dik 1989
Kratzer 1981
Ehrich 1992

Appendix 4. Formalism
This appendix deals with various formal aspects and extensions of event calculus.

Model theory
The completeness of a logic for a class of models does not entail categoricity. Soundness says every model satisfies one or more theories. Completeness says every consistent theory has one or more models. Being complete wrt a model class means that some quotient of the model class is isomorphic with some quotient of the logic. Because of the coarsening, completeness is only a rough map between the language and the models. A logic is categorical if theories and models are isomorphic. First order (or elementary) logic is complete but not categorical with respect to its models. (Löwenheim-Skolem). Elementary equivalence is a coarse equivalence on first order models. Axiomatisability is another thing, it has to do with enumeration. An axiomatisable theory is enumerable, so it has only countably many model classes. If there are more models than that, the theory can't be categorical. Decidability is even weaker: both truths non-truths can be enumerated. Boolean algebra is decidable and categorical with respect to point sets (Stone). Both =1, <1 are enumerable. Relation algebra is axiomatisable but not decidable nor representable.

Type theory is complete wrt general models. General models include full models and more. By allowing more models in, we lose mathematical truths, for all general models don't satisfy math. For instance, they don't all have the objects one feels should be there, not enough sets.
There are many variants to the model theory sketched here. van Benthem (1982:§1.3), defines a period structure as an ordered triple \((I, \mathcal{E}, \prec)\) of a set \(I\) of periods carrying two binary relations for inclusion and precedence, and goes on to constrain the triple with axioms. His \(\mathcal{E}\) corresponds to my relation in (ibid.§I.4.fn 3). van Benthem's axioms for \(\mathcal{E}\) come close to the axioms of Boolean inclusion. Hamblin (1969:93ff) shows how to partially define Boolean operators in terms of concatenation of convex periods. These satisfy the universal Boolean axioms whenever join, meet and complement exist.

Link (1998) develops a lattice theoretic ontology of events. In its 1997 version (Link 1998:§12.4.2) it consists of a tuple \((A, P, T, E, R)\) where \(A\) is a lattice of individuals, \(P\) is a lattice of processes, \(T\) is a lattice of event types, \(E\) is a lattice of events, and \(R\) is a finite set of semantic roles. Each elementary event \(e = p|t\) is uniquely determined by a process \(p\) and an event type \(t\). Roles are ternary relations between events, event types, and individuals.

Three trace functions \(s, t, r\) are defined on \(P\) mapping processes to space, time, and roles, respectively. Two processes are trace-identical if they agree on their values for \(s, t, r\). An event \(e = p|t\) is also constituted by any trace-identical ‘thicker’ process \(p'\) containing \(p\). Dually, type assignments \(e:t\) are persistent so that \(e:t\) implies \(e':t'\) for any type \(t'\) subsuming \(t\). Type assignments are directly related to propositional connectives so that \(e:t\) iff not \(e':\neg t\), \(e:p\wedge q\) iff \(e:p\) and \(e:q\), and \(e:p\vee q\) iff \(e:p\) or \(e:q\).

Together, the axioms governing the APTER model validate the following principle between processes and event types:

\[
\text{If } p \text{ constitutes } p1::t1 \text{ and } p2::t2 \text{ then } p \text{ constitutes } p1 \cup p2::t1\cap t2
\]

This principle makes processes and event types are dually related, like my event tokens and event types. Link’s processes individuate events extensionally, while types classify them intensionally. Individual events are thus identified by a combination of matter and form (At. Met. VIII).

In my version, the role of the sets of simple event tokens \(S\) and complex event tokens \(R\) is to prevent the algebra of events from being the free algebra generated by the alphabet \(V\) of primitive events. Only a subset of all possible courses and combinations of events are real. This resembles the move from standard or full models to general or Henkin models in higher order logic. Analogously, the question arises what constraints we wish to impose on \(S\) and \(R\) in order to preserve logical truths about events. The laws of the extended of regular expressions hold to the extent \(R\) satisfies corresponding closure principles. An example is the law of cancellation

\[
ef \not\equiv ef \equiv ef \land f \not\equiv f
\]

This law imposes an existential principle of solvability on \(R\): for any complex event \(xy \in R\) containing an event token \(uv \in S\), there are complex event tokens \(x, y \in R\) containing event tokens \(u \in x, v \in y\).

To reflect granularity, I prefer partial models to sets of total ones. Courses of events need not be connected nor comparable in general. Both events and times may remain unordered, but the order of times must embed the order of events:

\[
\text{If } x \in t \text{ and } y \in u \text{ and } xy \in R \text{ then } t \prec u \in T
\]

In the fully specified extreme, every course of events can be embedded into single universal time \(T\) consisting of a linearly ordered set of instants.

To allow for modality, reality \(R\) is divided up into smaller situations or possible worlds \(w \in W\). The main property of possible worlds \(w\) is that they are possible, i.e. consistent: \(ef\neg ef\wedge w = \emptyset\) for any event type \(e\) and possible world \(w\). An event type \(e\) is true at event type \(t\) if \(ef\neg t\) is nonempty. \(e\) is possible if \(e\) is nonempty. For instance, a counterfactual conditional is a conditional whose antecedent is false but possible in some sense.

Stronger notions of possibility arise by imposing order on \(W\).

The MSO connection between logic and automata and the method of model checking through translation into finite automata yields a (dis)proof procedure for the regular fragment of the event type calculus. To do deduction on event types, stronger methods are needed. One interesting thought is to consider structural deduction on regular expressions as term rewriting or tree transduction.

**Booleans**

The free product algebra of two event types \(a, b\) is a 16-element algebra \(16 = \{1, a\cup b, \neg(a\cap b), a, b, \neg a, \neg b, a\rightarrow b, b\rightarrow a, a\land b, a\lor b, a\cap b, \neg(a\cup b), \emptyset\}\) of the binary Booleans. This reduces to the non-free algebra \(2^4 = 8\) with three atoms and eight distinct elements if two independent atoms in \(a, b, \neg a, \neg b\) are made disjoint. This reduces further to \(4\) when \(a\cap b\) equals \(\emptyset\) (a and \(b\) are disjoint) or \(1\) (a includes \(b\): all or vice versa). This reduces down to \(2\) when \(a = b\). Further reduction causes contradiction \(0 = 1\). All these reductions except the last represent quotients or morphisms of Boolean algebras.
This development is an example of the product-coproduct duality in Boolean algebras. The algebras 2, 4, 8, 16... are isomorphic to binary numbers or characteristic functions of sets. By the Stone representation theorem, every Boolean algebra can be represented in this way.

Call a monotone (increasing or decreasing) mapping \(Q\) from 2 to 2 a 0-ary Boolean quantifier.\(^{274}\) There are two nondegenerate cases, identity defined by \(Q(1) = 1\) and complement defined by \(Q(\emptyset) = 1\). A monotone mapping \(Q\) from 4 to 2 is a unary Boolean quantifier. There are four nondegenerate cases, increasing quantifiers all defined by \(Q(1) = 1\), some \(Q(\emptyset) = \emptyset\) and their complements no \(Q(\emptyset) = 1\) and not all \(Q(1) = \emptyset\). A monotone mapping \(Q\) from 16 to 2 is a binary Boolean quantifier. Say \(Q\) is on a when \(Q(x) = Q(a|\emptyset)x\). The nondegenerate binary quantifiers on a are all \(Q(a \rightarrow b) = 1\), some \(Q(a|b) = 1\) (increasing) and no \(Q(a|\emptyset)b = \emptyset\), not all \(Q(a|b) = 1\) (decreasing).

Boolean operators and Boolean relations fall together in the domain of the initial Boolean algebra 2, for in this algebra, operators in \(2^{2x2}\) are relations. Conjunction \(\land\) is the equivalence relation containing only the pair \(1\) and \(1\). Equivalence \(\leftrightarrow\) is the identity relation \(=\) in 2. Its complement \(+\) is inequality \(\neq\). Disjunction \(\lor\) is symmetric but not reflexive or transitive. The relation \(\rightarrow\) is a partial order (reflexive, antisymmetric and transitive). For Boolean relations in 2, symmetric equals commutative. For instance, \(\leftarrow = \iff\). Going down, \(2 = 2^{x1}\) has two relations \(\emptyset\) and \(1\). \(\emptyset\) is asymmetric and symmetric at once.

The asymmetric binary Boolean connectives are \(a \rightarrow b\) and \(b \rightarrow a\). Asymmetry implies irreflexivity, so 0-0 and 1-1 must give 0. This leaves just two asymmetric options, 0-1 and 1-0 = 0 or the other way round. Looking at it another way, the only order relations in 16 are \(\rightarrow\) and its converse \(\leftarrow\) which are antisymmetric. Of the corresponding strict orders \(\rightarrow\) and \(\leftarrow\) equals \(b\land a\) and \(a\land \leftarrow\) equals \(a\land b\).

I extend usual notation with composite infix operators like \(\land a\land b\). There are other four groups (see appendix on relation algebra), but this one will come up later.

Boolean equations form a four group between all (unit) \(a = 1\) or \(\neg a\), none (empty) \(a = \emptyset\), some (positive) \(a > \emptyset\) or \(? a\), and not all \(a < 1\).

- **all** \(a = 1\) no \(a = \emptyset\)
- **some** \(a > \emptyset\) not all \(a < 1\)

Boolean relations form a four group between inclusion a \(\subseteq b\), exclusion a \(\nsubseteq b\), nonempty meet a \(\vee b\), and non-inclusion a \(\nsubseteq b\). There are other four groups (see appendix on relation algebra), but this one will come up later.

- **all** \(a \rightarrow b = 1\) no \(a \cap b = \emptyset\)
- **some** \(a \cap b > \emptyset\) not all \(a \rightarrow b < 1\)

These quantifiers are Boolean relations, so we can take complements, converses, duals, or compositions of them. For instance \(\neg(a \subseteq b) = (a \nsubseteq b) = a \nsubseteq b = a\land b > \emptyset\).

Take a Boolean algebra like 16 and form the equivalence classes of its elements under automorphisms, i.e. by cardinality \(0, 1, 2, 3, 4\). The free Boolean algebra of these classes as generators (atoms) is a linearly ordered Boolean algebra 32 of quantifiers between none and all four. For instance, all or none is \(0\lor 4\), exactly one is \(1\), at most two is \(0\lor 1\lor 2\), three is all four but one is \(3\). The null element of the algebra is NaN (not a number), and the unit element is any number \(0\lor 1\lor 2\lor 3\lor 4\). Cutting off \(0\) and \(4\) we get a Boolean algebra isomorphic to 8 of quantifiers between at least one and all three (all four but one).

The lattice of nonempty elements obtained by removing \(\emptyset\) from a Boolean algebra is not closed under meets or complements. It has been studied by Link (1988, 1998). Compare also the algebra of proper plurality obtained by removing atoms as well as \(\emptyset\).

Here is a table containing useful truths about Boolean implication related to the Hilbert axioms. Boolean multiplication is symbolised here with concatenation. To be an axiom is to be equal to unity.

<table>
<thead>
<tr>
<th>Hilbert axiom ((= 1))</th>
<th>equivalent to</th>
<th>ring equality</th>
<th>interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td>a (\land 1)</td>
<td>a = a, a (\subseteq 1), (1/a = 1)</td>
<td>1 is identity</td>
<td>1 is top</td>
</tr>
<tr>
<td>a (\lor 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{274}\)Boolean morphisms (Halmos 1974:35, MacLane 1967:500) are upward monotone (preserve null, unit and \(<\)). I extend the notion here with the dual mappings which invert null, unit and \(<\) to allow for complements \(\neg\), \(\neg\) all of the positive quantifiers some, all.
a ⊆ a

(a ⊇ 1) a, a ⊆ a, ¬a ∪ a, a + a + 1

a/a = 1

a ⊇ 1 is meet inverse

identity, reflexivity, bivalence

(a ⊇ b) ∩ (b ⊇ c) ⊆ a ∩ c

ab = 1, ab ⊆ a (a/b)/a = 1/b = 1

a/b = a, a + a + 1

a is left decreasing

cancellation

(b ∩ c) ∩ (a ∩ b) ⊆ a ∩ c

⊆ is transitive

composition, transitivity

(a ∩ b) ∩ c ≑ (a ∩ b) ⊇ c

(b ∩ a) ∩ (a ∩ b)

(a ∩ b) ∩ a

a(a ∩ b) = b a(a/b) = b

cut, modus ponens cancellation

((a ∩ b) ∩ c) ∩ (a ∩ c)

double negation

Peirce’s law

((a ∩ b) ∩ a) ∩ a

Table 98

In 2, quotient a/b and residual a ↣ b fall together when defined, for the modulus is always ⊥. The quotient 1/a equals 1 so it is not a true inverse (not unique). Of quotients in 2, ⊥/1 = ⊥, 1/1 = 1. Boole in effect defines 1/⊥ = 2 and ⊥/⊥ = x (Boole 1858:§6).

Exponent and logarithm reduce in Booleans to residual as well: a^b = b → a, so 2^⊥ is two’s complement: 2^⊥ = ⊥ → 1 = 1 and 2^⊥ = ⊥ = 1 → ⊥ = ⊥. On the other hand, log_b a = a → b, so b^log_b a = ((a → b) → b) = a. This is another case of adjunction (Pratt 1997).

Considering Booleans as one-place operators, we have the identities

(b) \^2 = (b \cap)  
(b →)^2 = (b \cup)

(b \cap)^2 = (b \cap)  
(b \cup)^2 = (b \cup) \cap (b)^2 = (b)

(→b)^2 = Id  
(b +)^2 = Id

As for relation compositions, the following hold:

A \^0 A = A  
→^0 \rightarrow = \rightarrow  
→^0 \leftarrow = \leftarrow^0 \leftarrow = \leftarrow^0 \rightarrow = \rightarrow

∧ \^0 V = \leftarrow \rightarrow \rightarrow  
\^0 \emptyset = \emptyset  
a \^0 \emptyset b = a

av^0 Ab = a →^0 Ab = b

Boolean sum is associative. Its value is the Boolean sum of its terms. Boolean equivalence is associative too. As complement of Boolean sum, its value is the Boolean sum of its terms plus 1. A three-way sum in 2 equals a three way equivalence: p + q + r = p ↔ q ↔ r.
The maximum length of a sum of disjoint terms in a Boolean algebra is the number of atoms. A sum longer than that cycles so it includes terms which have nonnull meets. For instance the two-valued sum \( p+q+r \) is not only true when just one of the terms is true but also when all three are. It follows that the following distribution principle fails for sums (it holds for join and meet, and for a binary sum; and from right to left):

\[
x \in a + x \in b + x \in c = x \in a + b + c
\]

The reason is that the Boolean algebra sum cycles after two terms in 2, while the Boolean algebra 8 does not. The distribution rule for Boolean sum over product would seem to be

\[
x \in a + x \in b + x \in c = x \in a + b + c
\]

It also follows that binary Boolean sum does not define the natural language associative either-or meaning that exactly one of a number of alternatives holds, nor does \( p \leftrightarrow q \leftrightarrow r \) mean that \( p,q,r \) are equivalent. The natural language either-or ‘just one’ is not associative. It is not monotone either, so it has no inductive definition in terms of binary either-or. This is a vindication of sorts of the natural language grammar of the connective either(or … or … or) which treats or as an associative operator and expresses uniqueness once over the set of options. Formally, this either-or may be represented as \( 1(x + \ldots + z) \) where 1 is a quantifier over the sum \( (x + \ldots + z) \).

**Priorities**

Priority operators satisfy the following (in)equalities:

\[
(e \circ f) \cap g = (e \cap g \circ f) \cap g
\]

\[
((e \circ f) \cap g) \cap f = f \circ g
\]

\[
(e \circ f) \cap (f \circ g) = (e \circ f) \cap (e \circ f)
\]

\[
e \cap f \cap e \cap g \subseteq e \cap f \cap g
\]

\[
e \cap f \circ g \subseteq e \cap f \circ e \cap g
\]

\[
1 \cap e \cap f \cap g \subseteq (e \circ f)
\]

\[
(e \circ f) \cap (f \circ g) \cap (f \circ g) \subseteq (e \circ f)
\]

**Factoring**

Consider solving terms of the forms \( a \cap b \). What we can say for sure is

\[
a \cap b = a \cap c/b \cdot a \cap c \cap b
\]

The question is whether the factors \( a \cap c/b \) and \( a \cap c \cap b \) have a positive expression. If \( c \) is idempotent, they do: meet distributes over concatenation, we get just

\[
a \cap b = a \cap c \cdot b \cap c
\]

Otherwise, Conway’s theorem says it has one given a common alphabet (factoring into atoms). A three element Boolean algebra is factored into eight atoms,

\[
(a \cap b \cap c) + (b \cap c) + (c \cap a) + (a \cap b \cap c) + (b \cap c \cap a) + (c \cap a \cap b) + a \cap b \cap c + \emptyset
\]

call the first seven for brevity A-G. In this factorisation, \( a \) is A+B+D+F+G, \( b \) is B+D+E+G and \( c \) is C+E+F+G. Then \( a \cap b \cap c \) is

\[
(A+D+F+G)+(B+D+E+G) \cap C+E+F+G =
\]

\[
((AB+AD+AE+AG)+(DB+DD+DE+DG)+(FB+FD+FE+FG)+(GB+GD+GE+GG)) \cap
\]

\[
(C+E+F+G)
\]

The event types A-G are Boolean atoms. If they are concatenation atoms too, we have hit rock bottom.

**Proof by resolution**

There is an association between the notion of resolution as a partition and the Boolean proof method of resolution, through the Boolean cancellation rule \( (a+b) + (b+c) = a+(b+b)+c = a+c \). This is a resolution or cut principle which allows canceling multiples from a Boolean sum.
The parametric representation of events as functions of time allows applying Boolean proof techniques to concatenation structures. One way of exploiting the projection is

$$ac \cup bd = ((au \cap tc) \cup (bu \cap td)) \cap tu$$

The parametric representation of events using time variables $t,u$ allow separating Boolean structure from order. This allows bringing the disjunctive event type on the left to a conjunctive normal form:

$$(au \cup td) \cap (bu \cup tc)$$

For instance, assuming $a,b,c,d$ are disjoint, it is possible to apply resolution proof techniques to show that event type $ac \cup bd$ entails the event type $(a \cup b)(c \cup d)$.

The dualisation method used here appears in literature in many guises. It appears as the Maxwell-Kaplan dualisation of propositional logic through nogoods (Maxwell/Kaplan 1991). The nogood transform uses the following Boolean theorem:

$$a \cup b = (p \rightarrow a) \cap (\neg p \rightarrow b)$$

That is, if two things are alternatives, there must be some condition that separates them. A four-way choice

$$(a \cup b) \cap (c \cup d)$$

can be resolved with two variables:

$$(p \rightarrow a) \cap (\neg p \rightarrow b) \cap (q \rightarrow c) \cap (\neg q \rightarrow d)$$

Boolean constraints on the disjunctions translate to constraints on the context variables. For instance, constraining (meeting) the above with

$$p \cup q \cap p \leftrightarrow a \cap (c \cup d) \cap (a \cap b \rightarrow p + q)$$

One way of looking at the new propositional variables is that they name represent propositional models, or valuations. Calculating with models equals going to the dual of the original propositional logic. Solving $p$ and $q$ in the equation gives $p = ab$ and $q = cd$. A slight variation is the transform $p \rightarrow a \cap q \rightarrow b \cap p + q$ matches the resolution of concatenation in time variables above.

Another variant is the well known transformation of Cantone et al. (2001) to reduce formulas into conjunctive normal form. It is based on the equivalences

$$p \leftrightarrow a \cup b$$
$$p \leftrightarrow a \cap b$$

To rewrite a formula of disjunctive form

$$(a \cap b) \cup (c \cap d)$$

to conjunctive form, replace the offending disjuncts recursively with fresh variables.

$$p \cup q \cap p \leftrightarrow a \cap b \cap y \leftrightarrow c \cap d$$

and reduce the new equivalences further with the same rules.

**Boole**

Boole (1858) develops Boolean algebra relying on standard algebra. The starting point is the insight that Boolean algebra is the standard algebra of 0 and 1, where class terms are those satisfying the law of duality $x^2 = x$ or equivalently $x(1-x) = 0$. Unlike most moderns, Boole develops logic in the equational form $e = 0$ of standard algebra. For instance, Boolean quantifiers are expressed with identity and variables as follows.

$$\text{all } a \text{ are all } b \quad a = b \quad | \quad a = b$$
Boole develops a theory of solving Boolean equations in the absence of the cancellation law by brute force. He simply acts as if the law were available. The Boolean equation

\[ x = yz \]

is solved for \( z \)

\[ z = y/x \]

and developed algebraically using the law of duality \( x(1 \setminus x) = 0 \) to

\[ z = 1/1xy + 1/0 x(1\setminus y) + 0/0(1x)(1\setminus y) \]

Indeterminate factors \( 1/0 \) and \( 0/0 \) are allowed to arise in Boolean equations and given interpretation as follows.

\[
\begin{align*}
1/1 &= 1 \\
0/1 &= 0 \\
0/0 &= v \\
1/0 &= 2
\end{align*}
\]

Boole gets round the problem of meet having no unique inverse by going higher in abstraction: Factor \( 1/0 \) says that the other factor is identically \( 0 \), so it is a Boolean quantifier. Factor \( 0/0 \) reads "any proportion", so it corresponds to an existential quantifier over quantifiers, doubly dual to a free variable \( v \).

Variable elimination from a Boolean equation is allowed by the Boolean theorem

\[ fx = 0 \text{ entails } f0 \setminus f1 = 0 \]

For instance, all men are mortal is represented by \( \text{men} = x\setminus \text{mortal} \), where the variable \( x \) is eliminated as follows:

\[
\begin{align*}
\text{men}\setminus x\setminus \text{mortal} &= 0 \\
(\text{men}\setminus 1 \setminus \text{mortal}) \setminus (\text{men}\setminus 0 \setminus \text{mortal}) &= 0 \\
\text{men}\setminus \text{mortal} \setminus \text{men} &= 0 \\
\text{men} &= \text{mortal} \setminus \text{men} \\
\text{men} &\subseteq \text{mortal}
\end{align*}
\]

Summing equations is licensed by theorems which show that equations whose left side satisfies the law of duality can be summed. If the left side of an equation \( e = 0 \) does not satisfy the law, its square \( e^2 = 0 \) will. For instance, some men are mortal does not satisfy the law according to Boole, for the second and third lines below differ by a factor of \( 2xb \setminus 2xab \). (These factors do vanish if the law of nilpotence \( 2e = 0 \) is used, but Boole does not use it.)

\[
\begin{align*}
xa &= xb \\
xa\setminus xb &= 0 \\
(xa\setminus xb)^2 &= 0 \\
xa\setminus 2xab + xb &= 0 \\
xa(1\setminus b) + xb(1\setminus a) &= 0
\end{align*}
\]

The last form says it is not true that no men are mortal or no mortals are men.

Boole’s propositional logic is modeled after his logic of classes. Material, conditional is defined as indefinite quantification over times at which propositions are true. if \( p \) then \( q \) means the time \( p \) holds is some (perhaps empty) part of the time at which \( q \) holds.

\[ p = xq \]

Here \( x \) resolves to \( p \), for \( p \rightarrow q \) is equivalent with \( p \leftrightarrow p \setminus q \). This formulation fits the traditional terms: condition \( p \) is what is ‘said with’ the consequent \( q \) that ‘follows with’ it.

Boole points out, once more, that (i) conversion is a special case of solving an equation for an unknown, or abstracting a variable, and that (ii) syllogism is a special case of substitution, which is the same thing as adding two equations and deleting a variable. The former is direct proof, the latter is resolution proof.
\[ a = xb \text{ and } b = yc \text{ entail } a = yc. \]

\[ a \setminus b = 0 \text{ and } b \setminus c = 0 \text{ entail } a \setminus b + b \setminus c = 0 \text{ and } a \setminus c = 0 \]

**Logic of regular algebra**

Simple regular expressions consist of alphabet, concatenation, union and Kleene star. The language of simple regular expressions is complete relative to the class of finite automata in that both devices define the same sets of words. Regular expressions are closed under complementation, so extended regular expressions define the same languages as simple regexps. (It follows that complement and intersection are eliminable relative to a given alphabet, i.e. events that can be expressed can be expressed positively for a fixed alphabet.)

For each regexp there is an effective way to construct a finite transition graph that defines the same language and vice versa. (Algebraically, transition graphs constitute finite (cyclic) semigroups, and the realisation relation is a semigroup morphism, Rozenberg and Salomaa 1997.) An isomorphism exists between extended regular expressions and a generalisation of nondeterministic finite automata known as Boolean finite automata (Rozenberg and Salomaa 1997). For each graph there is an effective way to construct a unique equivalent minimised deterministic graph. An algebraic completeness proof using matrices is given in Kozen (1994).

Nonequational finite or recursive equational axiomatisations exist for regular expression equations true of all regular languages (Salomaa 1973:50, Aho/Ullman 1972, Antimirov/Mosses 1994). All regular expression equations are solvable but the set of solutions may be infinite. However, there is always a fixpoint solution (Aho/Ullman 1972). Pratt (1990) characterises star using Segerberg’s (1977) induction axiom in the form of the following inequalities:

\[ f \cup e \leq e \leq f \cup e \ast \a
10. \( \Leftrightarrow \) \( e = e \)  
11. \( \Leftrightarrow \) \( ef = e.f \cup e \Leftrightarrow f \cup e \Leftrightarrow f \)  
12. \( \Leftrightarrow (e^*) = e\langle u \parallel e \parallel \Leftrightarrow x e / x < \)  
13. \( \Leftrightarrow (e:f) = e \not\vDash f \)  
14. \( e\not\vDash f \not\vDash g \) = \( (e\not\vDash f) \not\vDash (e\not\vDash g) \)  
15. \( e(f \not\vDash g) = ef \not\vDash eg \)  
16. \( (e \not\vDash f)^* = (e^f)^e \)  
17. \( (e^f)^* = (e*f)^* \)  
18. \( (e \not\vDash f)^* = e^* \not\vDash f \not\vDash (e^f)^* \not\vDash f \) \( (f^e)^* \not\vDash f \)  
19. \( (ef)^* = \boxempty \not\vDash e \not\vDash (fe)^* \not\vDash f \)  
20. \( e(fe)^* = (ef)*e \)  
21. \( (ef)^* = ef \not\vDash e \not\vDash (fe)^* \not\vDash f \)  
22. \( e^* = e^* \)  
23. \( e^* = e^* \)  
24. \( e^* = e^* \not\vDash e \not\vDash (0, a) \)  
25. \( e^* = e^* \not\vDash e \not\vDash (0, a) \)  
26. \( \Leftrightarrow (e \not\vDash g)^* \)  

Complement is self-dual  
Concatenation complement  
Iteration complement  
Context complement  
Booleans distribute  
Concatenation distributes over join  
Starred join  
Starred join too  
Iterated join  
Starred concatenation  
Starred concatenation too  
Iterated concatenation  
Star is idempotent  
Iteration is idempotent  
Factorisation of star  
Factorisation of iteration  
Compactness  

One can apply model set methods (Hintikka 1969) using auxiliary time variables \( t \) which identify events taking place at the same time. A set of events is inconsistent if it contains \( ef \not\vDash t \) and \( \neg ef \not\vDash t \) for some \( t \).

Rule 9 holds iff \( e \) is primitive, i.e. not a finite iteration of some other event type \( f \). (A simple test of primitivity is that \( e \) does not occur properly inside \( ee \).) In other words, iteration can be eliminated for Booleans if and only if the expression defines a noncounting language, Rozenberg and Salomaa (1997:16-17). The event type \( xe / x \) is known as the conjugate (cyclic permutation) of \( e \).

A related proof method is given in Antimirov/Mosses (1994) where a tableau or sequent of form \( e = f \Rightarrow 1 \) is simplified using equational axioms including those given above until either \( 1 \Rightarrow 1 \) or \( 1 \Rightarrow \emptyset \) is reached. Note the coinductive hypothesis on the third line which is matched on the last but second line. Example:

\[
\begin{align*}
b(ab)^* &= (ba)^*b & \Rightarrow & 1 \\
b(ab)^* &= ba(ba)^*b + \emptyset^* & = 1 \\
(ab)^* &= a(ba)^*b + \emptyset^* & = (ba)^*b \\
ab(ab)^* + \emptyset^* &= a(ba)^*b + \emptyset^* & = b(ab)^* = ba(ba)^*b + \emptyset^* \\
b(ab)^* + \emptyset^* &= (ba)^*b + \emptyset^* & = b(ab)^* = (ba)^*b \\
b(ab)^* &= (ba)^*b & = (ba)^*b \\
1 & \Rightarrow & 1
\end{align*}
\]

Consider Booleans over concatenation. First take the complement of \( ef \) relative to regular algebra \( 1 \). Intuitively, what \( ef \) says is that \( e \) is immediately followed by \( f \). Looking at it more carefully, an event type \( ef \not\vDash t \) equals \( ef \not\vDash f \not\vDash v \) for some \( uv = t \), which says that there is a match of \( e \) with \( u \) and \( t \) with \( v \) so that \( uv = t \). Denying this is not another claim of existence of a match, but the denial of the existence of a contradictory match. There may be an event type which matches \( t \) just when there is no match of \( t \) with \( ef \). However, that event type is not likely to be a simple concatenation. Given \( ef \not\vDash t \) means

\[
t \not\vDash (ef \not\vDash u.f \not\vDash v)
\]

denies its negation

\[
t \not\vDash uv \rightarrow (e \not\vDash u) \cup (\neg f \not\vDash v)
\]

For example, \( \neg (\neg e \not\vDash f) \) equals \( e \not\vDash u \leftrightarrow \not\vDash f \), whose meet with \( \not\vDash f \) equals \( ef \), as required by the theorem asserted in the section on liveness and safety.

\[
ef = \neg(\neg e \not\vDash f) \cap ef = \neg(\neg e \not\vDash f) \cap e < \\
\neg(ef) = ef \not\vDash e < = e < e \not\vDash \neg f
\]
The regular algebra complement of an atom $a$ is the coatom $1^*a = 1^0 + (1^\bot a) + 1^2.$ The regular algebra complement of a pair $ab$ is the language $1^*ab = 1^{1(1)} + (1^\bot a)b + a(1^\bot b) + (1^\bot a)(1^\bot b) + 1^{1(2)}.$

For the unpacking of $e\cap fg$ there is a factorisation theorem which asserts the existence of a (minimal but not unique) factorisation

$$e\cap fg = U((I\cap f),(g\cap r))$$

in a finite set of regular left and right factors $I,r$ of $e$ (event types s.t. $I<r \subseteq e$). The factors can be computed by induction on the composition of $e$ taking derivatives by the rule

$$ae \cap bf = a\cap b.e\cap f$$

which holds when $a$ and $b$ are concatenation atoms (Brzozowski 1964, Conway 1971:55, Antimirov/Mosses 1994, Salomaa/Yu 2000:172). Any event type $e$ can be written in the form $af$ for a concatenation atom $a$. A useful rule in teasing out a derivative is rule 16 $(ab)^* = a(ba)^* b \cup \emptyset^*.$

Quotient $eff$ satisfies the following rules (Conway 1971:43):

$$\begin{align*}
(e\phi f)/g &= e/g \phi f/g \\
e/fg &= (e/f)/g \\
e/f^g &= e(f/g) \phi (e/(g/e))^* \\
e^*/g &= e^*(e/(g/e^*)) \phi (\square^* \mathcal{R}g)
\end{align*}$$

Concatenation, star, meet and join are monotone with respect to $\subseteq$. (Cohen/Smith 1995) Concatenation and star satisfy cancellation $(ef = \emptyset$ entails $e = \emptyset$ or $f = \emptyset$, $e^* = \emptyset$ entails $e = \emptyset$), but Booleans do not.

Consider the composition of the no later than relation $\leq$ with itself. $\leq$ is reflexive and transitive, so $\leq^2 = \leq = \leq^*$. The event type $e\leq e$ is the type of two (not necessarily distinct) instances of $e$ where one begins and ends before the other one does, so it allows complete match, partial overlap, or separation. The composition closure of $e$ relative to $\leq$, notated by $e\leq e^*$, is thus the event type of nil or more matching, overlapping, or sequential tokens of $e$. Analogously $e\leq^* e^*$ denotes a positive number of tokens. This relation is regular for regular $e$. For instance, with $a$ atom, $a\leq^* a$ denotes $1^*$, $(aa)^* = e$ equals $(1(1)a)a^*(1(1a))^*$ which excludes solitary $a$'s.

$e\leq^*$ is defined in terms of Booleans and variables as $e\leq^* f$. This suggests implementing $\leq^*$ by a Boolean finite automaton. We may also define $e\leq^*$ in terms of concatenation and its inverse as $e.(\neq e)^* e$ which says to read $e$, read backwards some suffix of $e$, and read $e$ again. This suggests implementing $\leq^*$ by a two-way finite automaton (Hopcroft/Ullman 1979:36).

There is no complete equational proof theory for the shuffle operator (Szepietowski 1999).

**Transition types**

Take for instance the automaton representing the language $a(baUc)^*$. The automaton can be described as the relation algebra expression

$$xay \cap ybx \cap ycy$$

What I want to prove is that this relation algebraic expression denotes the same relation as the regular expression over relations

$$xa(baUc)^* y$$

How come they are the same? Well, by relation algebra, $yey$, then $yec^*y$ as well, for reflexive relations are closed under composition closure. This is another facet of the fact that a cycle in an automaton corresponds to a star in a regular expression.\(^{276}\)

Similarly, if $xay \cap ybx$, then $xay \cap ybx$ by relation composition, and by reflexivity again $x(ba)^* y$. Combining these results, we get $x(ba)^* x \cap xey = x((ba)^*Uc^*)y$ and further $y(baUc)^* y$. Because $xay$, we get $x(baUc)^* y$. The distribution rule applied here is

$$xay \cap xby = x(aUb)y$$

\(^{276}\) Compare the Kirchhoff cycle-star duality. Is it a coincidence that Kleene used star as the symbol of iteration? I hope not.
An epsilon arc expresses an inclusion relation $x \subseteq y$. A two-way epsilon arc (inclusion) equals identity $x = y$ alias $x \cup y$. An initial state is represented by an epsilon arc from zero and a final state by an epsilon arc to unit. Then the relation representing the automaton is

$$\emptyset \cup (ba uc) \subseteq 1 = a (ba uc)^*$$

We are dealing with one and the same algebra under different wrappers.

An atom of relation algebra is a relation $xay$ between two states labeled by an atomic relation symbol (Ladkin/Maddux 1994). The coatom automaton is calculated in relation algebra terms as a Boolean difference by

$$1 =$$

$$\emptyset \subseteq x \cup x_x \cap x \subseteq 1 =$$

$$\emptyset \subseteq x \cup x_s x \cap x_a \cup x \subseteq 1 =$$

$$\emptyset \subseteq x \cup x_s x \cap x \subseteq 1 \cap x_y \cap y_* x =$$

$$\emptyset \subseteq x \cup x_s x \cap x \subseteq 1 \cap x (a \cup \neg a) y + y_* x =$$

$$\emptyset \subseteq x \cup x_s x \cap x \subseteq 1 \cup x a y \cap x (\neg a) y \cap y_* x$$

$$1 - a = \emptyset \subseteq x \cup x_s x \cap x \subseteq 1 \cap x (\neg a) y \cap y_y \cap y_* x$$

Here the atom $xay$ occurs in a sum and can be subtracted. For the subtraction it was not necessary to unpack the star in $y_* x$. Doing it just shows that the remainder can be rewritten as an automaton for the coatom in the original alphabet.

The translation to relation algebra gives a method for proving regular algebra equations. Take for instance the well known identity

$$(a \cup b)^* = (a*b*)^*$$

The shared automaton is coded by the event type $x a x \cap x b x = x (a \cup b) x = x (a \cup b)^* x$. Apply star introduction to get $x a^* x \cap x b^* x$, then composition to get $x (a*b*)^* x$, and then star introduction again $x (a*b*)^* x$.

It can be used to prove automata transformations. Removal of epsilon arcs rewrites the transition space using the relation algebra identity $a = a \cup a^* a^*$. Determinisation refines or multiplies out the state space so that the transition relations become functions. The transition relation is not a function if it includes $x a y \cap x a z$. It becomes a function again when this case is coded as $x a (y \cup z)$. The coding uses weak distribution, dual to the strong distribution rule for regular expressions above.

$$xay \cup xaz = xa(y \cup z)$$

The initial state of the dfa is the sum of the initial states of the nfa and it has a transition from any sum of states to the sum of states which have that transition from a member of the first sum. Thus dfa keeps track in its state of all transitions possible to the nfa could be at any given time. Doesn't this sound familiar to modal logic? This is just the same transformation that happens when a Boolean relation is turned into a Boolean function through the isomorphism $2^{2^7} = (2^7)^2$.

Take example 2.5 from Hopcroft/Ullman 1979. Written in relation algebra form it is the event type

$$\emptyset \subseteq x \cup xax \cap xay \cap xby \cap yby \cap ybx \cap y \subseteq 1$$

which corresponds to the regular expression

$$(a^* (a \cup b)^* b)^*$$

It is nondeterministic thanks to the pairs $xax \cap xay$ and $yby \cap ybx$. It can be rewritten into an equivalent deterministic event type by introducing the join $x \cup y$ the states $x$ and $y$ as a new state $z$. The solution is not unique, but there is a unique smallest one among them. The one produced by the Hopcroft/Ullman algorithm is

$$\emptyset \subseteq x \cap x \subseteq 1 \cup xaz \cap zaz \cap zby \cap z \subseteq 1 \cup xby \cup zby$$

which corresponds to the regular expression

$$a (a \cup b)^*$$

This is not minimal. Note that state $y$ is dead (it has no way out). Another one is obtained by starting from the original statement of the automaton, adding the join state $z$ and stating everything that holds of it on given the original automaton and the weak distribution principle:

$$\emptyset \subseteq x \cup xax \cap xay \cap xby \cap yby \cap ybx \cap y \subseteq 1$$

$$\emptyset \subseteq x \cup xax \cap xay \cap xby \cap yby \cap ybx \cap y \subseteq 1$$

$$\emptyset \subseteq x \cup xzaz \cap zaz \cap zby \cap z \subseteq 1$$
It can be inspected that the event type thus obtained is equivalent to the original event type. It also happens to be the smallest event type that does so, i.e. the minimal deterministic automaton for the language at hand, equivalent to the regular expression \((a\cup b)^*\).

**State types**

The previous section showed how to generalise finite state automata from that special case where the events and states are both atomic to the case where the transitions are complex types (regular expressions). In this section, I consider the dual generalisation of finite state automata where the states of the automaton are not atomic, but Boolean combinations. This generalisation is known as *Boolean (alias alternating) automata* (Leiss 1981,1985, van Zijl 1997).

In the standard construction, the transition function of a Boolean automaton maps atomic states and events to Boolean relations. This corresponds to permuting the type of the transition function from \(\text{state} \rightarrow \text{event} \rightarrow \text{state}\) to \(\text{state} \rightarrow \text{state} \rightarrow \text{event}\). We can also consider a Boolean automaton as an automaton whose states are Boolean vectors of states, that is, state types. The transition relations associated to events are thus functions in \(\text{state} \rightarrow (\text{state} \times \text{event}) \rightarrow \text{state}\).

Any such system of equations has a unique constant solution for each state variable. The solution for the initial state is determined by the initial conditions, and the solution for a general state is determined by the equations. The corresponding Boolean automaton needs \(\log m\) states. Setting \(m = 2\) we get the atomic automaton

\[\emptyset \leq s \times (s+a)(s+b) \leq 1\]

This is a Boolean equation (see section on function algebra):

\[x = a^{-1}(y \land z) + \emptyset \land y = a^{-1}z + b^{-1}(y \land z) \land z = a^{-1}(y \lor x) + b^{-1}(y \lor x) + \emptyset^*\]

Any such system of equations has a unique constant solution for each state variable. The solution for the initial state is determined by the initial conditions, and the solution for a general state is determined by the equations. The corresponding Boolean automaton needs \(\log m\) states. Setting \(m = 2\) we get the atomic automaton

\[\emptyset \leq 0 \leq 0 \leq 1 \leq 1 \leq 0 \leq 1 \leq 0 \leq 1\]

This event type is deterministic and produces language \(((a+c)c^*(a+b)b^*)^*\). The reverse automaton is

\[\emptyset \leq 0 \leq 0 \leq 0 \leq 0 \leq 1 \leq 1 \leq 1 \leq 0 \leq 0\]
which is nondeterministic and produces the reverse language \((b^* (b+a)c^*(c+a))^*\). The corresponding deterministic automaton has 4 states. The corresponding Boolean automaton specified in relation algebra with variables is the two-state automaton

\[ \emptyset \leq 0 \leq 1 \leq \emptyset \]

To run this machine from an initial element, take any transition whose source element meets the initial element and move to the corresponding target element. At the end, the element obtained must meet with a final element. The rule \( xa = x \) above says to move from a state type to its complement. The two other rules allow moving to any state.

Salomaa et al. (2000) show how to implement an automata calculus based on deterministic Boolean automata.

**Boolean regular algebra**

The general view that emerges here is a generalisation of automata as an event type from atoms to Booleans.

Finite automata and regular languages are dual. The minimal finite automaton producing a given regular language can be turned into a regular expression which generalises as little about the language as possible. It can be compared to a disjunctive normal form regular expression. Every state in it defines a sublanguage and all the sublanguages are disjoint. They partition the language into equivalence classes under the Nerode equivalence relation \( xe = ye \). The language of the machine is the sum of those of its initial states. Consider the states of the minimal automaton as a new alphabet. This alphabet is dual to the original one. Any regular expression equivalent to the minimal one in the original alphabet corresponds to one in the dual alphabet. This is the linear algebra or matrix duality or the duality of edges and vertices of a graph.

Take for instance the minimal automaton producing the language \((ab)^*\). It has two states 1+2 and two transitions \( 1a2+2b1 \). Dualising the states and the transitions, we get the automaton whose states are \( a+b \) and transitions \( a2b+b1a \). The language of states it produces is \( (12)^* \). The automaton for the state language is the dual of the automaton for the transition language. Dualising the automaton for the smallest counting language of even number \((aa)^* \) 1a2+2a1 does not give an isomorphic state automaton, because the transition space is smaller than the state space. There is a sense in which the states count transitions but not vice versa.

The state space of a deterministic automaton is minimised by taking its quotient under the Nerode equivalence \( xe = ye \). States which generate the same language are joined. Any state is equivalent to itself. States which the same transitions take to equivalent states are equivalent. Conversely, final and nonfinal states are distinguishable, and states which have the same transition to distinguishable states are distinguishable. Determinism of an automaton ensures that the regular expression representing it is extensive, or a partition, so that joins are disjoint sums. Subtraction of a language then can then happen by taking Boolean differences.

States in the Nerode equivalence cannot be distinguished by language. Relation algebra is unable to distinguish equivalence classes of its universe. Concatenation is a free product (cartesian product) in 1 but behaves like composition restricted to the universe of an automaton: \( ab \cap R = \emptyset \) does not entail \( a \cap R = \emptyset \) or \( b \cap R = \emptyset \).

The unit of the algebra of regular expressions is the regular expression \( 1 = _* \) for the universal language. Its automaton dual is the automaton for the universal language, one state so that all labels cycle through it. The atoms? They are the alphabet symbols. What are atoms of the algebra of automata? They are the smallest nonnull automata, i.e. the automata for the alphabet symbols. They are unit transitions, two different states and a labeled arc between them.

What is a coatom of the algebra of automata? It is the automaton which produces all strings but one alphabet symbol. What is it like? In a one symbol alphabet \( a \), the complement of one \( a \) is the set of strings of null or at least two \( a \). This is an automaton where the initial state is the final state (for null \( a \)) and where there is an intermediate state joined by two \( a \) arcs to a final state where \( a \) cycles.

What is the corresponding regular expression like? The first state generates epsilon, the next state nothing, and the last state is the universal language. So \( 1a = \emptyset^* + aa^* = \emptyset^* + aaa^* \), because \( 1 = \emptyset^* + a + aa + aaa^* = a^* \).

The automaton for coatom \( 1a \) ‘all events but \( a \)’ is the following. The initial state is final, the next state reached by \( a \) is noninitial and nonfinal, the next state reached from it by \( a \) is final and generates \( 1 \), the universal language. In addition there are arcs for all symbols but \( a \) from the initial state to the final state.

Why is this right? Because the universal language can be rewritten as the regular expression, and the automaton just described represents the regular expression

\[ 1 = _* = \emptyset^* + a + (\_a) + (\_)* \]

where the cycle of the universal language has been unfolded one step so that subtraction of \( a \) can be done.

The general insight obtained from this line of thought is this.
(ii) Event calculus allows calculating with nonatomic automata composed of transition types and state types, with the same methods as with the usual ‘atomic’ automata. This allows looking at event types as automata in a generalised way. For instance, the generalised automaton for ‘one symbol only’ is the two-state one-transition coatom automaton on the one-symbol alphabet

Event calculus thus codes regular expressions as well as automata. Automata on Boolean relations are at once nfa and dfa. A nfa in atoms is a dfa in the Boolean algebra generated by the atoms.

Determinisation is dual to turning an automaton to a regular expression. In turning an event type into a regular expression, we code the combinatorics into the transition space. In turning it into a deterministic automaton, we code transition space into the state space. In minimising an automaton, we take a quotient. This is just the type of abstract general perspective I am after. But there is more.

**Automata as event types**

The automaton governing the changes of weather produces the event type

\[
\text{sun (cause } \neg \text{rain cause } \neg \text{sun cause rain cause sun)*}
\]

which can be expanded to

\[
\text{sun (cause dry cause cloud cause rain cause clear cause sun)*}
\]

where \(\neg \text{rain}=\text{dry}\) and \(\text{rain}=\text{wet}\) and \(\neg \text{sun}=\text{cloud}\) and \(\text{clear}=\text{sun}\). It is generated among others by the following automaton, or generic event type

\[
(\text{dry } \land \langle \text{rain} \rangle \rightarrow \text{wet}) \land (\text{wet } \land \langle \text{sun} \rangle \rightarrow \text{dry})
\]

where \(\text{dry}\) and \(\text{wet}\) are treated as states and \(\text{rain}\) and \(\text{sun}\) are events (transitions) The two conditional event types represent automata transitions. What is a state and what is an event is up for grabs here, and so is what causes what. The automaton is a Horn sentence (a meet of chains of implications) which can be also written in the form

\[
\text{dry } \rightarrow \langle \text{rain} \rangle \rightarrow \text{wet } \land \text{wet } \rightarrow \langle \text{sun} \rangle \rightarrow \text{dry}
\]

which equals the cyclic sentence

\[
\text{dry } \rightarrow \langle \text{rain} \rangle \rightarrow \text{wet } \rightarrow \langle \text{sun} \rangle \rightarrow \text{dry}
\]

which in turn means that weather cycles by itself, it is a closed system. The automaton can also be written in a disjunctive normal form, or a tabular representation

\[
\text{dry.rain.wet } \lor \text{wet.sun.dry}
\]

**Rewriting types**

The above generalisation of automata to Boolean and regular algebra gives a feeling for changes of event alphabet. It is important for understanding how the same events can be described in different terms. This topic is related to that of rewriting a regular expression in terms of a given alphabet as a regular expression in another alphabet (Antimirov/Moses 19??, Calvanese et al. 19??). The problem of solving regular expression equations of form

\[
e(e_1...e_n) = f(f_1...f_m)
\]

where \(f\) is a regular expression on a derived alphabet of event types \(f_1...f_m\) is decidable. One method to solve it is to construct an automaton for the language \(f\) from the automata for \(e\) in \(e_1...e_n\) (Calvanese et al. 19??).

It is important to realise that the common algebraic structure of finite automata, regular expressions, and relational algebra are make all of them intertranslatable. The proof of equivalence of regular expressions and automata takes a regular expression and translates it to an equivalent automaton. The automaton can be determinised and minimised and translated back to another regular expression which represents the minimal automaton. More generally, automata as well as Boolean and regular operations on automata translate to regular expressions and operations on regular expressions representing the automata. Regular expressions are not only dual to automata, they can also represent automata and do their work.

In the morphism between regular algebra, automata theory and relation algebra, regular expression alphabet symbols are are labels on transitions, so they are relation labels. Alphabet labels are types of transitions.
Matrices and automata

A Kleene algebra over matrices (Kozen 1991, 1994) is another way to generalise finite automata to regular events (not just atoms). For instance, the product \( I.A.F \) of matrices representing a three-state automaton with initial states given by vector \( I = (1 \ 0 \ 0) \), transition matrix \( A = (0 \ a \ 0, \ 0 \ b \ c, \ 0 \ d \ 0) \), and final states \( F = (0 \ 1 \ 1) \) represents the regular event type \( a(b \cup c \cup d)^*e? \), when the elements \( a, b, \ldots \) are interpreted as event types (an algebra of languages).

A regular event in matrix form, representing a meet of complex event types, can be used to calculate future states from a given array of initial states. Regular events form a linear system, so the follower of each state only depends on that state and input.

An event type in matrix form is the vector space dual of an event type in regular expression form. More precisely, the vector space of states is dual to the space of event matrices. The matrix space is the set of finite state machines of an event alphabet. Its dual is a class of regular languages, i.e. (finite or infinite) sets of finite index. The states of the automata are bisimulation equivalent to prefix languages so the state vectors consists of finite sets of prefix languages. The dimension of the spaces is the index of the language, so that \( k \)-state automata, or \( k \) by \( k \) matrices, are dual to regular languages of index \( k \).

A regular event can be written into a matrix form. A category theoretic proof of the event-automaton equivalence using bisimulation or coinduction is given in Rutten (1995). The regexp-automata duality thus turns out to be an instance of the duality of vector spaces and linear equations.

Assume given a Kleene algebra of relations. The set of square matrices over a Kleene algebra forms a Kleene algebra as well. In particular, identity \( 1 \) is the diagonal (identity) matrix, \( \sim r \) the transpose of \( r \), and \( 1 \) the top matrix. Matrix multiplication corresponds to relation composition.

The dual (characteristic function) of a relation can be graphed as an adjacency matrix which maps pairs in the relation into \( 1 \) and the rest into \( 0 \). Relation composition corresponds to Boolean multiplication of adjacency matrices (Ladkin/Maddux 1994:463). A square matrix with values in \( 2 \) is a type \( t \leq 1 \). The domain \( 1^r \) of a relation \( r \) is the type defined by the Galois connection \( 1^r \leq a \iff r \leq a1 \). This definition agrees with the previous relational algebraic one. The definition of domain is extended to matrices by setting

\[
(1^rA)_{ij} = \bigcup_j 1^r(A_{ij})
\]

Left quotient (residual) is defined by the Galois connection

\[
ab \leq c \iff a \leq c/b.
\]

The definition is extended to matrices by setting

\[
(A/B)_{ij} = \bigcap_k (A_{ik}/B_{jk})
\]

It represents the input-output relation of a data flow diagram if they are interpreted as binary relations (an algebra of relations).

Call types \( p, q \) conjugated projections (Desharnais 2007) if \( \sim p.p = (=), \sim q.q = (=), p.\sim p \cap q.\sim q = (=), \) and \( \sim p.q = 1 \). Then the cartesian product \( r \times s \) is representable as the meet

\[
p.q.\sim p \cap q.s.\sim q
\]

This duality of representations appears also as the duality of vectors and linear equations and the duality of word order and cases in natural language.

Taking products of vector spaces corresponds to refinement between event types (going to a finer granularity). This can be used to add geometrical and physical detail to event type schemata.

Taking products of automata can be used to model complex interacting events along these lines. An example is defining a system of communicating automata as a product of simpler automata. I return to this theme in the section on event automata.

Similarly, we will be able to define complex diathesis types as regular expressions on simpler ones, interpreting concatenation as composition or matrix multiplication.

The logic-automaton connection

The relation between logic and automata (known as the automaton-logic connection, Morawietz/Cornell 1997) has generated an entire new field of computational logic around monadic second order logic (MSO logic). To put it simply, it is possible to do automatic inference on finite domains in principle about as efficiently as one can hope by model...
checking, i.e. by translating event types to automata and minimising them. An event type is empty if its minimal automaton has no state.

The language of MSO logic consists of

- Booleans for propositions
- Booleans for objects
- Existential quantifier \( \exists x : e \)
- Successor functions (one for strings, two for trees)

All of these are defined in the event calculus here. The first two items are included as is. The existential quantifier \( \forall \) is interdefinable with the abstraction operator as

\[ \forall x : e = \exists x : e = x : e > \emptyset \]

Existential quantification and abstraction define dual projections of a relation. Abstraction projects into one component of an assignment, existential quantification projects out of one component.

Successor functions allow characterising strings (one successor) and trees (two). Two successors are needed in the formalisation of branching future.

In the model checking implementation of MSO logic (e.g. Klarlund/Møller 1998), an assignment of values is a string of bit vectors. The components of each bit vector index set variables. Each bit vector “is” an object telling which variables it is assigned to belong. Conversely, the value of a variable is the set of objects which assign 1 to it. The denotation of an event type is a set of assignments, i.e. a language of objects. For instance, the denotation of \( x = y \) is a set of assignments whose bit strings for \( x \) and \( y \) are the same. The formula \( x \leq y \) translates to the regular language \((0:0 + 0:1 + 1:1)*\) where the left (upper) tape represents (the assignment to) \( x \) and the lower one \( y \).

Denotations can be equivalently represented by finite state automata. For instance, the automaton for \( \exists x : e \) is obtained through a projection operation which extracts \( x \) from the event type, resulting to a nondeterministic automaton which can be determinised and minimised. The expensive part of the decision procedure is determinisation caused by existential quantifiers.

The relation of MSO logic to event calculus is revealed by a translation of a regular expression like \((ef)^*\) into MSO (Klarlund/Møller 1998:23).

\[ \forall p: s \in p \land t \in p \land \forall v: v \in p \land v < w \land (\lor r: v < r \land r < w \rightarrow r \in \neg p) \rightarrow \forall u: vu \in e \land uw \in f \]

This formula says there is a state event type \( p \) which includes states \( s \) and \( t \) so that for any two consecutive states \( v, w \) in \( p \) there is a state \( u \) so that event type \( e \) holds from \( v \) to \( u \) and event type \( f \) holds from \( u \) to \( v \). In other words, the span between \( s \) and \( t \) is divided by states in \( p \) into a number of spans each of which is divided into spans of \( e \) and \( f \), respectively. The second order power comes from \( \forall p \) quantifying over types.

This translation exhibits dual switches which will be discussed further on. First, there is a duality between event types and propositions, shown in the choice of sharp vs. round connectives. Second, there is a duality between states and events, shown in the quantification over states vs. closed event types. It turns out that the choice between MSO and regular formulations of events is a choice between quantifying over states vs. transitions of a finite state automaton. Third, there is a duality between concatenation . and precedence <.

My principle here, as elsewhere, is not to choose sides on a duality. The above formalisation is valid event calculus as much as the regular expression it codes.

MSO logic serves to relate event calculus to modal and dynamic logic, whose model theory can be represented in second order logic. Through the theory of weak second order logic with successors, it also allows relating event calculus to the burgeoning field of tree languages, automata and transducers.

**Trees**

(sketch) Here I want to capture the MSO logic insight that tree structure constitutes a third dimension of generalisation of finite state automata, namely depth direction, which connects the following notions.

- tree automata, regular path expressions, context free languages
- 2nd order monadic logic with a second successor relation for dominance
- partial orders and comparison involves context-freeness (van Benthem)
- proper substitution, regular-like expressions (Salomaa)
This ties together the tree/order relation angle with the regular algebra angle. Given that the stack language of a stack automaton is regular, it is interesting to ask what languages are generated by stack automata whose stack language is noncounting. It is likely to connect up with the expressive power of tree automata. It may also connect up with the observation that natural languages avoid nesting of identical constructions, and the character of the marginal exceptions.

**Logc of relation algebra**

The laws of relation algebra (van Benthem 1991:230) include those of Boolean algebra, plus (for instance)

\[
\neg(r \cup s) = \neg r \cup \neg s \\
\neg \neg r = r \\
\neg \neg \neg r = \neg r \\
(r \cap s) \circ t = r \circ (s \cap t) \\
x \cap (y \cup z) = (x \cap y) \cup (x \cap z)
\]

The last two axioms characterise composition and converse. The last axiom is a triangle axiom describing a commutative triangle diagram of composition and converse (Peirce’s law, van Benthem 1991), more iconically represented by the De Morgan theorem K or Schröder equivalences (De Morgan 1864; Schröder 1895, Ladkin/Maddux 1994, Desharnais 2007)

\[
r^*s \subseteq t \iff \neg r^*t \subseteq s \iff \neg s \subseteq \neg r
\]

or the complement-free Schröder equivalences (Düntsch/Schmidt/Winter 2007?, Ladkin/Maddux 1994)

\[
(r^*s) \cap t = \emptyset \iff (\neg r^*s) \cap t = \emptyset \iff (s^*t) \cap r = \emptyset
\]

The axiomatisation in Ladkin/Maddux (1994) contains Boolean algebra

\[
x \cap y = x \cap x \\
x \cup y = (x \cup y) \cup x
\]

and the rest of relation algebra as

\[
(x^o y)^o z = x^o (y^o z) \\
x^o (=) = x \cup (=)^o x \\
\neg (x^o y) = \neg y^o \neg x \\
\neg (x \cup y) = \neg x \cup \neg y \\
\neg x^o = (x^o y)^o y = \emptyset
\]

The first four say converse and relation composition form an involuted monoid. The last three tie the monoid to Booleans (Ladkin/Maddux 1994:441). Here is one more variation of it:

\[
x \cap y^o z = x \cap (y \cap x^o \neg z) \cup (z \cap \neg y^o x) \text{ and } x^o \emptyset = \emptyset = \emptyset^o x
\]

Relation algebraic theorems include

\[
\neg \neg x = \neg x \\
\emptyset = \neg \emptyset \\
1 = \neg 1 \\
(=) = \neg (=)
\]

if \(x \subseteq y\) then \(-x \subseteq -y\) and \(x^o z \subseteq y^o z\) and \(z^o x \subseteq z^o y\)
The axiomatisation is complete with respect to general models of relation algebra where the universe 1 is an equivalence relation. There is no finite axiomatisation for full models where 1 is the cartesian product of the universe (Tarski 1977). There is no representation theorem for relation algebras as first order relations on sets analogous to Stone’s theorem for Boolean algebra (Lyndon 1950). There are more relation algebras than first order relations on sets. Representable relation algebras can be recursively (but not finitely) axiomatised (Lyndon 1955, Ladkin/Maddux 1994:442).

The operations of relation algebra form can be seen as relation combinators (Feferman 19??) analogous to function combinators in combinatory logic:

<table>
<thead>
<tr>
<th>definition</th>
<th>relation algebra</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$\text{x}x\text{x} = \text{x}$</td>
<td>unit, universal relation</td>
</tr>
<tr>
<td>K</td>
<td>$\text{x} = \text{y}$</td>
<td>left projection, antipassive</td>
</tr>
<tr>
<td>K2</td>
<td>$\text{y} = \text{x}$</td>
<td>right projection, passive</td>
</tr>
<tr>
<td>C</td>
<td>$\text{x} = \text{y}$</td>
<td>inverse, converse</td>
</tr>
<tr>
<td>W</td>
<td>$\text{x} = \text{x}$</td>
<td>identity, reflexive</td>
</tr>
<tr>
<td>B</td>
<td>$\text{x} = \text{x}$</td>
<td>composition, causative, transitive</td>
</tr>
</tbody>
</table>

The representation of an object type $a$ as its identity relation translates to $W_1a$.

Relation algebra has been variously generalised to three place relations as relation operations. For further details see (Lyndon 1955, Baber 1994, Langford 1995, Tarski/Givant 1987).

**Atoms of relations**

**Absolute** object types, represented as subsets $x \subseteq (=) y$ of the identity relation, satisfy

\[
\text{if } x \subseteq (=) y \text{ then } x^o \cap y = x^o \cap y \text{ and } y^o \cap x = y^o \cap x
\]

An equivalence is a symmetric and transitive relation $e \equiv e \equiv e$. A relation algebra $a$ relativised to an equivalence $e$ is the algebra $a_e$ of all the of $a$ elements included in $e$. $a$ is also a relation algebra, in fact a quotient algebra of $a$. An equivalence relation is essentially a second order property. A cartesian relation is essentially a second order object. A relation algebra is simple when it is of form $2^a \times 2^b \times 2^c$ for a base (absolute object type) $b$. A simple algebra is representable. An example of a non-simple relation algebra is $2^a \times 2^b$. Note that $a^2 \times 2^b$ is an equivalence relation. This algebra is isomorphic with the product of two simple relation algebras $2^a \times (2^b \times 2^c)$. These observations relate to the representation of events as a product of descriptive dimensions (see section on linear algebra).

An atom of a relation algebra is an atom of its Boolean algebra, a relation $a$ so that $a \cap b = \emptyset$ or $ab = \emptyset$ for any relation $b$. If $a$ is an atom so is $\sim a$. In an atomic relation algebra, relation operations distribute to and are lifted from atomic relations. The algebra is determined by the identity relation, the converses and the multiplication table of compositions of atomic relations (Ladkin/Maddux 1994:442).

A smallest reflexive relation $r$ is a pair $ara$ where $a$ is an atom. It at the same time an atom of a universal relation. The largest reflexive relation is the universal relation $1$. Reflexity is preserved under joins and meets but not complements.

An smallest symmetric relation is the pair of pairs $arb \times bra$. It at the same time a universal relation. The unit symmetric relation is the universal relation. Symmetry is preserved under all Boolean operations.

A smallest transitive relation is a triple $arb \times brc \times arc$. It is also an atom of a cotransitive relation. Transitivity is preserved under meet and composition but not join or complement. Asymmetric and transitive entail acyclic. 0-cyclic says reflexive. 1-cyclic says nothing. 2-cyclic says transitive and cyclic (aperiodic). 0,-1,2-cyclic says equivalence relation. A universal relation is $k$-cyclic and $k$-cyclic for all $k$.

Let us survey some small relation algebras. (Ladkin/Maddux 1994). There is the trivial algebra $\emptyset = 1$ of one element, equal to the trivial Boolean algebra. The first nontrivial one is the two-element algebra, which is the Boolean algebra $2$ of $\{\emptyset, 1\}$. In this one, $\emptyset$ is the empty relation and the difference $\neq$, and $1$ is the universal relation and the identity. The base consists of one atom $a = 1$ which is identical to itself.
The next bigger one is the two-atom four-element relation algebra \(4\). The four relations in it are the empty relation, identity, difference, and the universal relation. The base consists of two distinct atoms, each different from the other and identical to itself. A curious feature lost in all bigger algebras is that the composition of two differences is identity:

\[(\neq)^2 = (\neq)\]  

Then comes point algebra, a three-atom eight-element relation algebra (Ladkin/Maddux 1994:444). Its atoms are identity \(=\), the order relation \(<\) and its converse \(>\). This algebra is just enough for order. The eight relations are \(\emptyset,=,\neq,<,\leq,>,\geq,1\), where \(1 = (\langle\rangle+\langle\rangle+\langle\rangle) = (\langle\rangle+\langle\rangle) = (\langle\rangle+\langle\rangle)\). The multiplication table of composition in point algebra goes:

<table>
<thead>
<tr>
<th>(\circ)</th>
<th>(=)</th>
<th>(\neq)</th>
<th>(&lt;)</th>
<th>(&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(=)</td>
<td>(\neq)</td>
<td>(&lt;)</td>
<td>(&gt;)</td>
<td></td>
</tr>
<tr>
<td>(\neq)</td>
<td>(&lt;)</td>
<td>(\leq)</td>
<td>(\geq)</td>
<td>(1)</td>
</tr>
<tr>
<td>(&lt;)</td>
<td>(\leq)</td>
<td>(\geq)</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(&gt;)</td>
<td>(\geq)</td>
<td>(\leq)</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Composition of order converses amounts to \(1\). One reflex of this is the natural language fact that past future and future past (quod vide) do not place an event on the time line and are thus free to signal modal meanings. Point algebra corresponds to dense linear order without endpoints. Note that the point algebra is finite but the time line that represents it is infinite (Ladkin/Maddux 1994:445).

The containment algebra is the five-atom relation algebra whose atoms are identity \(=\), inclusion \(\subseteq\), its converse \(\supseteq\), overlap \(\subsetneq\) and disjointness \(\subsetneq\). Its multiplication table is given below:

<table>
<thead>
<tr>
<th>(\circ)</th>
<th>(=)</th>
<th>(\subseteq)</th>
<th>(\supseteq)</th>
<th>(\subsetneq)</th>
<th>(\subsetneq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(=)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subsetneq)</td>
<td>(\subsetneq)</td>
<td>(\subsetneq)</td>
</tr>
<tr>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
</tr>
<tr>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
</tr>
<tr>
<td>(\subsetneq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
</tr>
<tr>
<td>(\subsetneq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
<td>(\subseteq)</td>
<td>(\supseteq)</td>
</tr>
</tbody>
</table>

This is the relation algebra of Boolean inclusion.

The interval algebra is the thirteen-atom relation algebra of four points on a line. It represents relations between intervals on a line. The atoms are the following seven relations plus their converses. The relations are those described in the section on order. My notation for each relation is given on the left. The names of the relations on the right are those of Ladkin/Maddux (1994). The two right hand columns specify the order of the boundary points \(x<y=t, z<w=u\) in the interval representation and the converse relation, respectively.

<table>
<thead>
<tr>
<th>type</th>
<th>relation</th>
<th>endpoints</th>
<th>converse</th>
<th>Ladkin/Maddux 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(\cap)u</td>
<td>simultaneity (x=z\neq y=w)</td>
<td>(\cap,=,\cap)</td>
<td>equals (t)</td>
<td></td>
</tr>
<tr>
<td>t«</td>
<td>proper separation (x\neq y\neq z&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>precedes (p)</td>
<td></td>
</tr>
<tr>
<td>«t</td>
<td>proper infix (z\neq x\neq y&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>during (d)</td>
<td></td>
</tr>
<tr>
<td>«t\u00a0</td>
<td>proper overlap (x\neq y&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>overlaps (o)</td>
<td></td>
</tr>
<tr>
<td>t\u00a0</td>
<td>contiguity (x\neq z\neq y&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>meets (m)</td>
<td></td>
</tr>
<tr>
<td>t«</td>
<td>proper prefix (x\neq y\neq z&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>starts (s)</td>
<td></td>
</tr>
<tr>
<td>«t\u00a0</td>
<td>proper suffix (z\neq x\neq y&lt;w)</td>
<td>(\cap,=,\cap)</td>
<td>finishes (f)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 99**
The following sums of atomic relations appear in the 13x13 multiplication table for composition:

<table>
<thead>
<tr>
<th>type</th>
<th>sum of atoms</th>
<th>endpoints</th>
<th>converse</th>
<th>Ladkin/Maddux 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(\cap)u</td>
<td>(x=z\neq y\neq w)</td>
<td>(\cap,=,\cap)</td>
<td>equals (= \alpha = p+o+m)</td>
<td></td>
</tr>
</tbody>
</table>
For «, first define <as ¬¬« and «as «¬» and then define concatenation with

\[ \forall a \exists b : a < b \]
For \( \| \alpha \| \), first define \( \prec \) as \( \| \alpha \| \setminus (\| \alpha \| \setminus \| \alpha \|) \).

Interval algebra reduces to point algebra by defining \( \ll \ll \) to the sum \( \bigcap \ll \ll \) to the sum \( \bigcup \ll \ll \) and disjointness to the sum \( \ll \ll \). The hard algebra of Ladkin/Maddux (1994) is related to numeral quantifiers.

## Relation types
Relation algebra allows characterising types of relations (Quine 1963:22-23, van Benthem 1991:237-238). Here is a list. These characterisations can be compared to their analogues in function algebra.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r \subseteq r )</td>
<td>reflexive</td>
</tr>
<tr>
<td>( r^0 \subseteq r^1 )</td>
<td>irreflexive</td>
</tr>
<tr>
<td>( r^0 \subseteq r )</td>
<td>coreflexive</td>
</tr>
<tr>
<td>( r^0 \subseteq r^0 )</td>
<td>almost reflexive</td>
</tr>
<tr>
<td>( r = r \rightarrow r^0 )</td>
<td>(co)symmetric</td>
</tr>
<tr>
<td>( r' = r \rightarrow r^1 )</td>
<td>(co)symmetric</td>
</tr>
<tr>
<td>( r' \rightarrow r = r^0 )</td>
<td>asymmetric</td>
</tr>
<tr>
<td>( r^2 \subseteq r^2 )</td>
<td>transitive, 2-cyclic</td>
</tr>
<tr>
<td>( r^2 \subseteq r^2 )</td>
<td>euclidean</td>
</tr>
<tr>
<td>( r^3 \subseteq r^3 )</td>
<td>antieuculidean</td>
</tr>
<tr>
<td>( r^4 \subseteq r^4 )</td>
<td>circular (van Benthem 1986)</td>
</tr>
<tr>
<td>( r^5 \subseteq r^5 )</td>
<td>cotransitive, almost connected</td>
</tr>
<tr>
<td>( r^6 \subseteq r^6 )</td>
<td>linear</td>
</tr>
<tr>
<td>( r^7 \subseteq r^7 )</td>
<td>total (relation)</td>
</tr>
<tr>
<td>( r^8 \subseteq r^8 )</td>
<td>closed</td>
</tr>
<tr>
<td>( r^9 \subseteq r^9 )</td>
<td>connected</td>
</tr>
<tr>
<td>( r^{10} \subseteq r^{10} )</td>
<td>weakly connected</td>
</tr>
<tr>
<td>( r^{11} \subseteq r^{11} )</td>
<td>strongly connected</td>
</tr>
<tr>
<td>( r^{12} \subseteq r^{12} )</td>
<td>cyclic, aperiodic</td>
</tr>
<tr>
<td>( r^{13} \subseteq r^{13} )</td>
<td>acyclic</td>
</tr>
<tr>
<td>( r^{14} \subseteq r^{14} )</td>
<td>1-cyclic</td>
</tr>
<tr>
<td>( r^{15} \subseteq r^{15} )</td>
<td>k-cyclic</td>
</tr>
<tr>
<td>( r^{16} \subseteq r^{16} )</td>
<td>k-cyclo-pic</td>
</tr>
<tr>
<td>( r^{17} \subseteq r^{17} )</td>
<td>almost universal</td>
</tr>
<tr>
<td>( r^{18} \subseteq r^{18} )</td>
<td>quasiporder</td>
</tr>
<tr>
<td>( r^{19} \subseteq r^{19} )</td>
<td>preorder</td>
</tr>
<tr>
<td>( r^{20} \subseteq r^{20} )</td>
<td>equivalence</td>
</tr>
<tr>
<td>( r^{21} \subseteq r^{21} )</td>
<td>cartesian product, universal</td>
</tr>
</tbody>
</table>

Relation types form an algebra of their own.

The reflexive closure of a relation \( r \) is \( r \cup r^0 \) where \( r^0 \) is the diagonal of \( r \). The symmetric closure of a relation \( r \) is \( r \cup r \) and \( r \cap r \) is the symmetric kernel of \( r \). The associated indifference relation is \( \{ (r \cap \neg r) \}. The transitive closure of \( r \) is \( r^* \). The reflexive transitive closure of \( r \) is \( r^t \). The simplest equivalence relation which includes \( r \) is its reflexive, symmetric and transitive closure \( (r \cup \neg r)^* \).

Domain, codomain and field of an equivalence relation are the same. An equivalence relation is a partition of the field into universal relations. Identity is the finest equivalence, universal relation the largest. A similarity is a reflexive and symmetric relation. A cover is a join of universal relations whose join is \( 1 \). A cover is a similarity. For instance adjacent is a cover of times.

The complement of an equivalence relation is reflexive, cosymmetric and cotransitive. A weakly connected cosymmetric and cotransitive relation is irreflexive. Such a relation may be called a reciprocal relation. The finest reciprocal relation is \( \neg \). The largest reciprocal relation is the universal reciprocal relation \( 1 \). An example of a reciprocal relation is a partition of a field into nonunit cycles. Another example is a strict order.

The maximal reciprocal relation is also the irreflexive symmetric relation formed a total order and its converse. The universal relation is the sum of two strict total orders and identity. This is easy to see from the dual of the relation, its adjacency matrix \( Z \) (cf. linear algebra below). In the matrix, identity is the diagonal. An order relation is an antisymmetric transitive relation represented by convex region on one side of the adjacency matrix. A maximal order relation is a total or linear relation which corresponds to a full half triangle of the adjacency matrix. The diagonal is the identity (equality, indifference) relation, excluded from a strict order and included in its complement. It is easy to see
that relation converse and complement commute by \( \neg r = \sim r \). A reflexive region includes the diagonal. A symmetric relation is symmetric over the diagonal. A transitive relation is a convex region in the matrix. An equivalence is a convex region including the diagonal.

A quasiorder is reflexive and symmetric. A preorder is a reflexive and transitive. A (strict) partial order is reflexive, transitive and antisymmetric. A weak order is transitive and cotransitive, which means its indiscernibility is an equivalence. A linear/order is a linear/order partial order, or a partial order whose complement is a partial order, or a weak order whose indiscernibility is identity.

An equivalence is a symmetric preorder. It is self-inverse and idempotent under composition. Antisymmetric and linear are complementary (Westerståhl 1989:85). The contrary of transitive is intransitive \( r^* \subseteq \neg r \). This includes the relation next.

Identity relations and universal relations each form a Boolean algebra, with Booleans defined through the one-one mapping between the relations and their fields. Projections are also one-one images of the corresponding domain, so projection relations form Boolean algebras as well.

Relation algebra identity, universal relation, and left and right projections form a category theoretical square diagram with identity relation and universal relation as product and coproduct and the projections as adjoints. There is a Galois connection between projection and cartesian product

\[
1 \uparrow r \subseteq a \text{ iff } r \subseteq ax1
\]

There is a correspondence between the Boolean unary quantifiers all, all but one, one and none and the relation types of universal relation, reciprocal unit, identity and the empty relation. Compare the relations everybody loves everybody, everybody loves each other, everybody loves themselves and nobody loves anybody.

Cartesian product satisfies the identity \( 1 = axb + ax \neg b + \neg axb + \neg ax \neg b \). Compare to the Boolean identity \( 1 = a \neg b + a \neg b + \neg a \neg b + \neg a \neg b \). This is an instance of the isomorphism between Boolean sum and direct product of Boolean algebras. Compare section on negation.

The algebra of binary relations will explain why intransitive (antipassive), reflexive and reciprocal are interchangeable in natural language. They do not denote the same, but they carry the same information about a relation. If people love at all, then they love somebody, themselves or one another. It explains which types of relations become one-place event types in the plural. See section on the typology of diathesis.

Function types can be defined in the same fashion.

\[
\begin{align*}
zfx &= zfy \rightarrow x = y & \text{function} \\
xfz &= yfz \rightarrow x = y & \text{co-function (injective, one-one)} \\
1f &= 1 & \text{total (function)} \\
f1 &= 1 & \text{co-total (surjective, onto)}
\end{align*}
\]

These definitions are equivalent to the usual ones. The definition of injection says \( fx = fy \rightarrow x = y \) in prefix function notation. A bijection is all four. A bijection on Boolean atoms is also bijective on their sums. A function on atoms is not necessarily a function on other elements.

Relation types can also be extended to relational algebra and formal language theory, where it connects to varieties of languages. A n-place generalisation of relational composition is the event type \( e^nf = yz; e[;y;x;]zf;f \) which projects shared suffixes and prefixes out of the concatenation of two event types. The composition is proper if \( x \) is not \( \emptyset \). Improper composition coincides with concatenation, when \( x = \emptyset \). Improper composition closure equals \( e^* \). The copy language \( xx \) is an identity of composition.

Call an event type transitive if it is closed under composition. A transitive event type satisfies \( ee \subseteq e \), is prefix closed and suffix closed.

Call event type e reflexive if it satisfies \( e \subseteq ee \). A reflexive event type is atomless or contains \( \emptyset \). An improper transitive event type is reflexive for \( \emptyset \subseteq x^x \). The 0-place relation \( \emptyset \) is at once reflexive, symmetric and transitive. An improper transitive event type is reflexive and idempotent so \( \emptyset \subseteq e \) and \( e^* = e \).

Call e symmetric if it satisfies \( e^1 = e \). The mirror image language \( xx^1 \) of palindromes is symmetric. A reflexive, symmetric, and transitive event type is closed under factors and concatenation, so it is commutative (closed under permutation, Schnoebelen 1999). An example is a simple state.
Resolution
Fuzzy logic (Zadeh 19??) is an approach to genericity, vagueness or perception which relates metric or comparative concepts to absolute ones. The idea is at bottom the algebraic insight that multiplying two-valued algebras gets algebras of arbitrary resolution.

The starting point is that the multiplication of two properties gives a relation. In general a relation is a fibred product of two properties, a subset of the cartesian product of domain and a codomain. What makes a property of pairs a binary relation is that it is not free, but fibred, subject to a law. The law is the relation.

In a comparative relations, the laws are those of (a(nti))symmetry and transitivity. Each amounts to excluding terms from the square of not small versus small ¬s+s, which is the fourfield of two-way comparisons ¬s¬s+s¬s+s+s. Choosing ¬ss gets bigger. Leaving it out gets not smaller. Choosing s¬s gets smaller. Leaving it out gets not smaller. ss gets equal.

The three-element relation algebra allows defining transitivity by throwing out nontransitive cases. By transitivity if xy are ¬ss, and yz are ¬ss then xz are ¬ss. It follows that y is ¬s+s, big and small, or medium). Transitivity leaves three-way comparisons where the negation sign is monotone: ¬s¬s+s¬s+s+ss+sss. A transitive three-way comparison classifies three objects as small small (very small), small large (medium), and large large (very large). In a three way comparison, the middle one is large and small at once. In one or two elements, it is excluded.

In general, one gets a comparative relation out of a vector of classifications by arranging the cells by the number of positives. In shirt sizes, two distinctions of small versus big gives a four-way scale of extra small (smallest), small (smaller or smallish), big (bigger or biggish) and extra big (biggest). Sizes in between which are both big and small are medium. In terms of choice functions, the extra large are the large among the large. This too is a relation product, the second power of a choice function.

Convolution
A comparative change can be defined as a convolution of absolute changes, i.e. as a sum of shifted products. Take two absolute changes

\[
\text{from } ¬p \text{ to } p = ¬p.p
\]

and

\[
\text{from } ¬q \text{ to } q = ¬q.q
\]

Their convolution is

\[
¬p.¬p¬p¬p¬q¬q¬q¬q ¬q¬q¬q¬q ¬p¬p¬p¬p¬p¬p¬q¬q¬q¬q
\]

which is the event type

\[
¬p¬p¬q¬q¬p+pq¬p¬q¬q¬q¬q¬q¬q¬q
\]

in other words,

\[
\text{from } ¬p¬p¬q¬q \text{ by } p+q \text{ to } p¬p¬q¬q
\]

Let p,q be nested choice sets. Then we have a minimal comparative event type, with a tertium comparationis standing in the middle between two extremes.

Convolution defines a product space, hence increases resolution. It is the opposite of coarsening resolution by going into a quotient space. This is one facet of the mathematics of granularity. Convolution simplifies to product in the dual Fourier representation.

Superposition
There is a duality known as the complementarity principle or superposition principle mathematically based on the Fourier transformation. The Fourier transformation allows representing any piecewise smooth function with finite integral (a potential function) as a sum of periodic functions of different frequencies. This is the mathematics of the particle-wave duality of quantum physics.

The superposition principle has a reduct to regular events. ¬e.e¬e is a closed event type. Its iterate (¬e.e)+ is an open event type, defined by the complete join

\[
∪(¬e.e)^i e
\]

where i runs over positive natural numbers. Dually, the Fourier transform of the cycle ¬e.e¬e can be obtained as a superposition of open iterated event types of different periodicities.
\[ \cap_e (\neg e^* e) \]

Unpacking the above formula, we get an infinite meet of infinite joins.

\[ (\neg e^* e \U e \U e \U e \U e \U e \U e \U e \U e \U e) \cap (\neg e^* e \U e \U e \U e \U e \U e \U e \U e \U e \U e) \cap \ldots \]

As in the Fourier transform, peaks in the different periodicities cancel out. The meet event type reduces to

\[ \ldots \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset \emptyset = \emptyset^* \neg e^* \neg e^* = \neg e \neg e \]

An open event type is an infinite join of closed event types, and a closed event type is an infinite meet of open event types.

Consider history as a spectrum mapping from times and event types to \[2\], representing the presence or absence of \( e \) at a time as a Boolean amplitude of \( e \). The open components in the meet act as different periodicities (partials) of the composite event type. The amplitude spectrum of the original event assigns each partial an amplitude in \[2\] (present or not present). Thus the transient composite event can be seen as a set of periodic component events (and vice versa), related to one another as event and its dual (Manuch 1999).

There are two dualities involved in the Fourier transformation. One is a transpose of the Chu matrix of events and time between column major frequency order (events per time) and row major duration order (times per event). The second one replaces the dual of the original event type (amplitude per time) with its dual (amplitude per frequency) as just described. The result of a double dual is identity.

**Proof techniques for priority operators**

Since priority operators are reducible to Booleans, proofs concerning priorities can be conducted using any of the usual proof methods. In practice, it gets tiresome to deal with test events explicitly. A tabular technique for proving priority theorems can be based on the multiplication tables given in the section on priorities.

The task is to show that the lexicographic order of two preferences equals their priority meet:


Construct the multiplication table for the expressions to show equivalent. Equivalence holds if the columns of the two expressions are identical. (Only the essential part of the table is shown here.)

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**Table 102**

**Completeness and continuity**

A complete Boolean algebra adds infinitary versions of join and meet. Complete join \( \cup e \) and complete meet \( \cap e \) denote the top (lowest upper bound) and bottom (greatest lower bound) of \( e \) with respect to inclusion. These are strong operators which allow definition of fixpoints and continuity. For instance, completeness \( \cup \cap x = \cap \cup x \) in Boolean algebra says complete join and meet commute. It is is an infinitary version of distributivity Kleene star can be explicitly defined as the fixpoint \( \cap x^* = x \). Fixpoints give context-free event types, for instance the fixpoint \( \cap x^* = e f \) is the context free language of equal numbers of \( e \) and \( f \).

Continuity does not entail density. Discrete functions can be continuous (Scott/Stratchey 1971). Continuity is involved in adjacency, contact and smooth motion. Characterisations of continuity will come up in due course.

**Boolean linear algebra**

The *inner product* or *dot product* of two vectors is the sum of componentwise products. The *norm* of a vector is the square root of its dot product with itself (or dot square). Boolean algebra is idempotent, so square (root) does nothing. A Boolean vector space has a city block metric.
What is the dot product of two event types, represented as a vector of orthogonal Boolean spaces in a componentwise way? It should be the sum of the componentwise products. In vector algebra, the componentwise products and their sum belong to a dual space of scalars. Now it is clear what the componentwise products are: they are the meets of the corresponding components. But what is the dual space of scalars here? The values of the dimensions may not seem to come from the same space here: they are event types, object types, times, etcetera. But they are all projections of things of the same sort after all, namely event types. For instance, the scalar component of the time yesterday at noon is the type of events happening yesterday at noon. That is, the space of the scalars is simply the product space of events.

Then we can form the dot product $\text{rain here} \cdot \text{wind there}$ as

$$\text{rain \& wind somewhere} + \text{something here} \& \text{there}$$

Now for the interpretation. The dot product of two vectors measures their independence. In particular, the dimensions of the space of events should be orthogonal to one another. When they are, their dot product vanishes:

$$\text{rain nowhere} \cdot \text{nothing here} = \text{rain} \& \text{nothing} + \text{nowhere} \& \text{here} = \emptyset + \emptyset = \emptyset$$

What does the independence of the event types $\text{rain here}$ and $\text{wind there}$ mean? It says that the eventualities of rain and wind in one place and something happening here and there are not mutually exclusive. It is possible for it to rain and blow here and there at once, as well as possible for it to be dry or calm in one of the places.

The *distance* of two event types in Booleans equals their dot product. The *norm* or *length* of an event type is its dot product with itself. For one-dimensional event types, this is the event type itself. For two dimensional event types, it amounts to the sum

$$\text{rain here} \cdot \text{rain here} = \text{rain} \& \text{rain} + \text{here} \& \text{here} = \text{rain} + \text{here}.$$  

This excludes rain here, but expects that something happens here and rain happens somewhere. Given those premises, it falls together with the complement. The norm of an event type is its distance from $\emptyset$.

Take another example: the norm of the event type $\text{I win}$ in a two-person zero-sum game is $\text{I} + \text{win}$, which equals you win. The dot product $\text{I win} \cdot \text{you win} = 1$. The events are not independent, but complementary, their meet is $\emptyset$ and sum 1.

The *projection* of an event type to one of its dimensions is its dot product with the unit vector:

$$\text{rain here} \cdot \text{something nowhere} = \text{rain} \& \text{something} + \text{here} \& \text{nowhere} = \text{rain} + \emptyset = \text{rain}$$

it falls together with the event itself.

For two event types to be independent/orthogonal means that they belong to different attribute dimensions. Then the probability of their meet is the product of the probabilities of the events. For instance, the probability of a given player winning the game of Left and Right is the product of the probability of that player in the space of players (one half) and the probability of a win (one). The betting ratio in the game is fifty-fifty.

In a one-dimensional event space, dot product falls together with meet, so events wind and rain are independent if $\text{wind} \& \text{rain} = \emptyset$, i.e. they are relative atoms. The atoms of a Boolean algebra are linearly independent and constitute a base of the algebra.

Any Boolean polynomial in variables $e$ has a representation as a sum of products $\sum \Pi e$ (disjunctive normal form) or dually, a product of sums $\prod \Sigma e$ (conjunctive normal form). The product of 0 terms is 1. The atoms of the algebra form a basis of unit vectors. Any event has a componentwise representation in the basis as a sum of atoms.

**Probability**

This section charts the relation of probability to Boolean algebra. Probability involves counting tokens in types. It involves homomorphisms of Boolean algebras. Take a free Boolean algebra of some sum of tokens, take a (possibly uneven) partition of the tokens into types, and form a free Boolean algebra on that. The probability of an event (an element) of the type algebra is the number of tokens in it, divided by the number of all tokens.

Then take a product of two free Boolean algebras, do the same. Tokens are now pairs. The probability of a relation (a set of pairs) is the number of pairs in it divided by the number of all pairs. The latter is the product of the sizes of the two BAs. A relation is independent iff it is the cartesian product of two event types. This gives conditional probability and independence.

It follows from the above that probabilities of exclusive events can be summed and independent events can be multiplied. Exclusiveness and independence are dual.
Take the 3-element Boolean algebra of weather yesterday, today, and tomorrow. We map the event type rain→rain on it which gives 8 different distributions of rain on time. There is no even distribution here, all of them are uneven, because the space is odd.

Now distribute wind→wind on it too and ask whether wind is independent of rain. If the event types include or exclude one another, the events are not logically independent, and we are not doing probability yet. Probability involves comparing sizes of logically independent events in some algebra of tokens. If all rainy days are calm days, we are doing deduction. If there are both, but more calm rainy days than windy ones, we are doing induction and probability. Both are meets are nonempty but one is bigger, or more probable, than the other. If the events are independent, then all sizes are equal, and rain says nothing about wind or vice versa.

Say there is rain today and tomorrow, or two days out of three. Wind was yesterday and today. The product of the probabilities is 2/4, or about 0.4. The size of the meet is one out of three, which is 1/3, about 0.3. This shows that the events are not probabilistically independent. In this algebra, the events cannot be probabilistically independent unless both happen every day or not at all. If both happen always, the product is 1*1 = 1 and the relative size of the meet is also 1. If neither ever happens, the product is 0*0, and so is the size of meet. Independent events cannot be exclusive, except at the extreme: empty events are exclusive and independent at the same time.

The three element algebra is not a free Boolean algebra. Contingent events can be independent only in a free Boolean algebra whose number of atoms is a power of 2. Take four days and distribute rain and wind on them so that they are logically independent, say wind and no rain on Monday, wind and rain on Tuesday, rain and no wind on Wednesday, and calm and no rain on Thursday. Then the two event types are independent: the proportion of rainy days is ½, the same with wind, and one out of four days (Tuesday) is both, so its probability is ¼, so the event types are they are independent.

This algebra is the free two-feature product algebra of two free one-feature algebras, the first consisting of the two pairs of rainy days (Tuesday+Wednesday) and dry days (Monday+Tuesday) and the second of the pairs of windy days (Monday+Tuesday) and calm days (Wednesday+Thursday). The product algebra of these free two-atom algebras is the free four-atom algebra 16. Each day is characterised by a valuation in the two features rain and wind, which form a free base.

More generally, probability is theory of Boolean measurement. The de Finetti axioms of comparative probability and the associated representation theorem (de Finetti 1974-5, Fishburn 1986) relate qualitative or comparative probability to a probability measure, or real valued Boolean morphism in the interval 0≤1.

Probability is a Boolean morphism and a normalised metric on a Boolean space. It maps event types to the Boolean algebra of real numbers between 0 and 1. The map takes a refinement of the quotient of the space of events by a two-valued truth definition. A two-valued truth definition, or a two-valued metric with values in 2, is the initial object of the category of probability metrics. The distance of two events e,f in the two-valued metric 2 is their norm |e|=|e∩f|(fe) which equals their Boolean sum e+f. This satisfies the triangle inequality e+g ≤ (e+f)+(f+g) because f+f = ø.

A comparative probability structure is a relation ≥ as at least as likely as on a Boolean algebra B satisfying the conditions

- ≥ is a weak order (reflexive, transitive, total)
- ≥ is nonnegative: b≥ø for any b
- ≥ is additive: if a∩c = b∩c = ø, then a≥b entails (a∪c) ≥ (b∪c)

Then a probability measure p exists on B if there is a base (partition) of B in equiprobable atoms A, i.e. ∑A = 1 and A ≤ r(¬r).

For joint probabilities, there is the dual axiom

if a ⊥ b, c ⊥ d, a ≥¬c ≥ b, then b ≥ d entails a∩b ≥ c∩d

where the turnstile marks linear independence (see section on linear algebra). Together with measure theoretic solvability and comparability conditions, it licenses the representation theorem

a ⊥ b entails p(a∩b) = pab.

As a Boolean morphism, probability preserves sums:

pb = p1pb = p1(a∩b) = p((a+¬a)∩b) = p((a∩b)+(¬a∩b)) = p(a∩b)+p(¬a∩b)

Conditional probability p(a/b) = p(a∩b)/pb can be interchangeably seen as a Boolean measure on a quotient algebra, or the quotient algebra of a Boolean measure. Bayes’ theorem is a simple consequence of the definition and Boolean algebra.

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278 The requirement can be weakened in various ways for infinite probability spaces.
\[ p(a/b) = \frac{\text{pap}(b/a)}{\text{pap}(a/b)} + \frac{\text{p} \neg \text{ap}(b/\neg a)}{\text{p} \neg \text{ap}(a/\neg a)} \]

The numerator reduces by definition to \( p(a \cap b) \) and the denominator to \( pb \).

\[ \text{pap}(a \cap b)/\text{pap}(b/a) + \text{p}(\neg a \cap b)/\text{p}(\neg a) = p(a \cap b) + p(\neg a \cap b) = pb \]

*Probably* means *more likely than not*, \( pe > p(1|e) \) i.e. \( pe > \frac{1}{2} \). *Certainly* relates to *probably as all to most*. Probability and modality are related by one-way entailment: \*must* \( e \) or \( e = 1 \) entails \( pe = 1 \) and \( pe > 0 \) entails \( e > 0 \) or may \( p \) for any Boolean morphism \( p \). The converses do not hold. Note also the relation to *like* from the section on prototypes. An event is *like* another if it is close to it in a feature space. An event is *likely*, or *truthlike*, if it is close to 1 in a probability space.

The logic of *probably* as a modal logic is that of the quantifier *most* or the generic adverb *mostly*. De Finetti’s axioms for the dual notion conditional plausibility (*p allows q*) determine the dyadic (conditional) logic of *at least as many* (van Benthem 1986:86). It validates, among others, the following principle:

\[ p+q \text{ allow } q \rightarrow (q+r \text{ allow } r \rightarrow p+r \text{ allow } r) \]

This is a valid rule of choice function theory.

*Information* and its dual *entropy* measure the (un)evenness of a distribution of types in a space of tokens. Equivalently, it measures the volume (size) of the dual *phase space* which maps types to tokens. At the informative end only one type occupies the entire space. At the entropy end all types occur.

There is a probabilistic generalisation of the relation *cause* into Bayesian networks. An event is a probable cause of another if the conditional probability of the effect given the cause is above chance.

### Topological axiomatics

The logic of aspect can be gleaned from axiomatics for the associated topological notions. Topological closure is characterised by the Kuratowski axioms (Kelley 1953:43):

\[
\begin{align*}
\text{cl } \emptyset &= \emptyset \\
\text{e } &\subseteq \text{cl } e \\
\text{cl } \text{cl } e &= e \\
\text{cl } (e \cup f) &= \text{cl } e \cup \text{cl } f
\end{align*}
\]

Compare the section on function algebra. Topological interior \( \text{in} \) is characterised by the duals of these axioms, by the definition of interior as \( \neg \text{cl} \). Topological boundary \( \text{b} \) is characterised as the difference \( \text{cl } e \setminus \text{in } e \). Among theorems of this system are

\[
\begin{align*}
\text{in } e &\subseteq e \subseteq \text{cl } e \\
\text{in } e &\subseteq \text{cl } e \subseteq \text{cl } \text{in } e.
\end{align*}
\]

The identity in \( \text{cl } e = e \) holds for regular open sets Regular open sets form a Boolean algebra relative to usual meet and complement redefined as \( \neg \text{cl} \) (Boolos 1972:13).

There are further suggestive connections between topology and Boolean algebra besides the Stone representation theorem. van Benthem (1982:82) points out that the set of finite unions of convex subsets of a strict partial order form a full Boolean algebra. Halmos (1974) shows that the set of regular open sets in a topological space form a Boolean algebra when Boolean meet is set intersection and complement is defined as complement of closure as \( \text{cl } \neg a \). An open set is regular when it is the interior of its own closure. (Intuitively, a regular set has no cracks or holes.) The join of adjacent open sets is more than their set union, for it absorbs the points in between.

If \( a \) is a subset of a topological space, then at most 14 sets can be constructed from \( a \) by complementation and closure. There is a subset of the real numbers (with the usual topology) which 14 different sets can be so constructed. First notice that if \( a \) is the closure of an open set (i.e. regular), then \( a \) is the closure of the interior of \( a \); that is, for such sets \( a = \text{cl } \neg a \). (Kelley 1952:57). There are sixteen binary Booleans, counting constants 0 and 1 (Boolos 1974:21).

### Logic of since and until

By Kamp’s theorem (Kamp 1968, Burgess 1984) *since* and *until* are enough to define all first order definable tenses on the real line (see section on logical typology). As *since* and *until* suffice to define concatenation, Kamp’s theorem is tantamount to the theorem that first order events equal the closure of finite events under concatenation and Booleans, or noncounting (star-free) events (McNaughton/Prevert 1971), or the proof that all event types are in the meet of safe and live properties (proved by Plotkin in 1993, cf. Alpern/Schneider 1994).

*Since* and *until* obey, among others, the following rules (Burgess 1984:119):
Burgess (1984) shows that past and future are temporally separable (Gabbay 1983) in terms of since and until, so that any tense is a Boolean compound of formulas containing only one or the other. For logical purposes, it is thus enough to pay attention to the past or to the future, the other half is the mirror image. The proof uses the equivalences

\[
\text{g until e until f} = \text{g until f until e}
\]

\[
\text{g until e} \subseteq \text{g until f}
\]

\[
\text{e until f until g} = \text{e until g until f}
\]

\[
\neg(e \text{ since f}) = \text{lately f} \rightarrow (\neg e \text{ since } \neg f)
\]

For example the last axiom reads: If we have not been quarreling all the time since we got here, then we did not quarrel recently, or we have been elsewhere since we stopped quarreling. This rule bears comparison to the characterisation of until in terms of liveness and safety.

Alpern/Schneider (1985) note that \(e \text{ until f} \lor e.f\) is equal to the meet \(\neg(\neg e < f) \cap < f\) of the the safe property \(\neg(\neg e < f)\) ‘\(\neg e\) before \(f\) does not happen’ and the live property \(< f\) ‘eventually \(f\)’. The negation of until \(\neg (e \text{ until f})\) equals \(e < f \lor \neg < f\) alias \(< f \rightarrow \neg < f\), i.e. if \(\neg e\) will happen before \(f\) if \(f\) happens at all. Dually for \(\neg (e \text{ since f})\) which comes to \(f \leftarrow f \leftarrow e\), i.e. \(\neg e\) has happened after \(f\) if \(f\) happened at all.

The definition of not since applied in partially ordered time gives a logic of counterfactuals (van Benthem 1991:217). The proof that every process property is a meet of a safe and a live property is put in terms of event calculus as follows.

Let \(CL P\) be the smallest safety property containing \(P\) and let \(L\) be \(\neg (CL P \setminus P)\). Then

\[
L \cap CL P = \neg (CL P \setminus P) \cap CL P = (\neg CL P \cap CL P) \cup (CL P \cap CL P) = (CL P \cap CL P) = P.
\]

To show that \(L\) is a liveness property, i.e. dense, suppose for contradiction that there is a nonempty open set \(O\) contained in \(\neg L\) and thus \(L\) is not dense. Then \(O \subseteq (CL P \setminus P)\). Consequently, \(P \subseteq (P \setminus O)\). The meet of two closed sets is closed, so \(P \setminus O\) is closed and thus a safety property. This contradicts the hypothesis that \(CL P\) is the smallest safety property containing \(P\). QED.

**Logic of transduction**

The transduction relation : is associative so \(x:y:z = x:(y:z) = (x:y):z\). It satisfies the following equations:

\[
fx = fx:fx = f(x:fx) = (f:fx)x = (f:fx)(x:fx)
\]

Its logic can be exemplified by event type as follows.

\[
\begin{align*}
  e\cdot f &= e & \text{when e is free for f} \\
  e\cdot e &= e \\
  e\cdot (e\cdot f) &= f \\
  e\cdot \neg(e\cdot f) &= \neg(e\cdot f) \\
  (e\cdot f)\cdot g &= (e\cdot e\cdot f)\cdot g \\
  e\cdot g\cdot f\cdot g &= e\cdot (e\cdot uf) = e \\
  e\cdot g\cdot f\cdot g &= e\cdot (e\cdot uf) = e \\
  (e\cdot f\cdot g) &= e\cdot (e\cdot ef)g = ef \\
  (e\cdot g\cdot f\cdot g) &= (e\cdot f\cdot g) = e \\
  (e\cdot g\cdot f\cdot g) &= (e\cdot f\cdot g) = e
\end{align*}
\]

The right column reveals that the abstraction operator defines inverses. The abstraction operator also allows defining concatenation inverse \(a^{-1}\) as \(xax = \emptyset^\ast\), which takes event calculus outside regular languages and loses decidability. 279

The operation of proper substitution involved in abstraction is a context free operation (van Benthem 1991:109).

---

279 A Turing machine can be represented as an intersection of regular transducers.
Further rules:

27. \( e(f:g) = (ef):g \)

28. \( (e \& f):g = e:g \& f:g \)
29. \( (e:g).(f:h) = ef:gh \)
30. \( (e:g)^+ \subseteq e^+:g^+ \)

31. \( x:e = e\&\emptyset \leftrightarrow x \)
   if \( x \) is not free in \( e \)

32. \( x:x = \neg x::x = x = 1 \)
33. \( x:x = \neg x::x = \neg x = \emptyset \)
34. \( x:x \neg e = e\&x = e\&1 = e = \emptyset \)
35. \( x:x\&e = e\&\rightarrow x = e\&\rightarrow 1 = e > \emptyset \)
36. \( \cup(x:x\&e) = e \)
   subevent
37. \( e(x:exf)f = exf \)
   infix
38. \( (x:x)^+ = x^+ \)
   root of iteration

Conway (1971:§6). For instance, \( a(x:bx) = ax:bx = ax\&ax:bx = ax:ax\&ax:bx = ax:(a\&b)x = (a\&b)x:ax\&bx \) equals \( (a\&b)x \). Similarly, \( b\&(x:ax) \) equals \( (b\&x):ax \) equals \( b:ab \).

More combinatoric logic

Combinators include also

- \( S = xz(yz):xyz \) substitution, distribution
- \( \Phi = w(xz)/yz : wxyz \) right distribution, \( S' \)
- \( \Psi = w(xy)/xz: wxyz \) left distribution
- \( J = wx(wzy) : wxyz \) compose, copy and commute
- \( Y = Yx = xYx \) fixpoint

Rosser’s combinator \( J \) only needs identity \( I \) to define the rest. Each combinator is associated with well known algebraic operators or properties.

Finite iterations of a function can be defined by \( Z0f = KIf \), \( Zn+1f = SBZnf \) (Diller 1988:61) and iteration closure by the fixpoint operator \( Yf \). For instance, \( ancestor \) is the fixpoint \( Y father \) of \( father \); the father of an ancestor is an ancestor. It is the combinator synonym of Kleene star of composition.

There are many interdefinabilities between combinators, for instance:

- \( I = WK = SKK = CKC \)
- \( B = S(KS)K \)
- \( C = S(BBS)(KK) = JI \)
- \( S = B(B(BW)C)(BB) \)
- \( W = CSI = S(Cl) = SS(KI) = SS(SK) = C(S(CC)(CC)) \)
- \( \Phi = B(BS)B = B(B(B(B(BW)C)(BB))))B \)

\( K \) is not definable in terms of the rest.

Lambda abstraction \( \lambda \) as a combinator is characterised by the following equations:

- \( \lambda x : x = Ke \) when \( x \) is not free in \( e \)
- \( \lambda y : y = I \)
- \( \lambda x : e = e \)
- \( \lambda x : ef = Bef \) when \( x \) is not free in \( e \)
- \( \lambda x : ef = Cef \) when \( x \) is not free in \( f \)

A condition is that the bound variable is disjoint from the body of the lambda. Lambda \( \lambda \) and parentheses is another sufficient base for combinatory logic, as can be seen from the above tables.

Conversely, abstraction can be defined in terms of combinators. This is a way to implement lambda calculus (Curry/Feys 1958:190, Hindley/Seldin 1987:25, Diller 1988:88).
The bound variable in lambda does is indicate which argument is bound (cancelled). An alternative way to obtain the effect of lambda is to posit separate left and right projections $K1 = K$ and $K2 = K1K0 = K1$. The commutative combinator $C$ is then definable using $W$ and the projections, yielding another complete set of combinators:

$$B, W, K1 \text{ and } K2$$

compose, copy, left and right projection

This set can be compared to the relation algebraic primitives in Codd’s theorem (Codd 1972), the cylindric algebra operators, and the lot to the natural language operators of causative, reflexive, passive and antipassive.

Combinators relate the grammatical notions of constituent coordination and deletion (ellipsis). Constituent coordination involves distributive combinator $\Phi$ or its variants:

choose $x$ or $y = \text{choose } x \text{ or } \text{choose } y \quad \Phi \cup \text{choose } x \text{ and } \text{choose } y$

The same effects is obtained from a combination of the compose, copy and delete combinators $B$, $W$ and $K1$, $K2$ compose, copy and delete combinators.

The lesson is that there is a choice between ―base generation‖ and ―transformation‖. Compare the section on aboutness.

The basic binary combinators can be generalised to $n$-place ones in various ways. Combining with $I$ we get application, two-place inversion and duplication $BIXy = xy$, $CIXy = yx$ and $WIX = xx$.

Conversely, $B$ can be used to shift the effect of a combinator forward.. For instance, $Kxy = x$, $BKxy = K(xy)z = x$, $BBBxyzw = B(BK)xyzw = BK(xy)zw = K(xy)w = xyz$. In general, we may define the $n$th projection of a combinator as $X_0 = XI$ and $X_{n+1} = BX_n$. The powers and projections are related by the equation $X_{m+n} = B^{m}X_n$.

Iterating the process of generalisation, define $X_{[1]} = X$, $X_{[n+1]} = BX_{[n]}^{n}X$. Then for instance, $C_{[2]}fxyz = fxy$, a cyclic permutation. Analogously define $X_{[1]} = X$, $X_{[n+1]} = X^{n}BX_{[n]}$. Then for instance $\Phi_{[2]}fghxy = \Phi_{[2]}fghxy = fgxhxy$, a binary distributivity principle.


$$I \quad \text{a} \rightarrow \text{a} \quad \text{identity}$$

$$K \quad \text{a} \rightarrow \text{b} \rightarrow \text{a} \quad \text{cancellation, Hilbert axiom}$$

$$B \quad \text{a} \rightarrow \text{b} \rightarrow \text{c} \rightarrow \text{a} \rightarrow \text{c} \quad \text{conditionalisation, Geach rule}$$

$$S \quad \text{a} \rightarrow \text{b} \rightarrow \text{c} \rightarrow \text{a} \rightarrow \text{c} \quad \text{substitution, Hilbert axiom}$$

$$C \quad \text{a} \rightarrow \text{b} \rightarrow \text{c} \rightarrow \text{a} \rightarrow \text{b} \rightarrow \text{c} \quad \text{permutation}$$

$$W \quad \text{a} \rightarrow \text{b} \rightarrow \text{a} \rightarrow \text{b} \quad \text{duplication}$$

$$CI \quad \text{a} \rightarrow \text{b} \rightarrow \text{a} \rightarrow \text{b} \quad \text{dual, Montague}$$

$$CB \quad \text{a} \rightarrow \text{b} \rightarrow \text{a} \rightarrow \text{b} \rightarrow \text{a} \rightarrow \text{c} \rightarrow \text{a} \rightarrow \text{c} \quad \text{permuted composition}$$

$$SKSI \quad \text{a} \rightarrow \text{b} \rightarrow \text{a} \rightarrow \text{b} \quad \text{application, Ajdukiewicz}$$
The type formulas above are right associative.

**K** and **S** correspond to Hilbert’s two axioms for implicational logic (van Benthem 1991: 36, 79). The basic combinators correspond to structural inference rules of reflexivity (**I**), cut (**B**), permutation (**C**), contraction (**K**) and monotonicity (**W**), which characterise classical inference (van Benthem 1996:143). Various dynamic calculi, such as Lambek calculus, linear, relevant, and intuitionistic logic constrain the application of such structural rules (van Benthem 1996:252). For instance, an axiomatics for undirected Lambek calculus consists of **I**, **C**, **B**, and the application rule (cut, modus ponens) restricted to apply once per premise (van Benthem 1991:77).

Combinatory logic becomes inconsistent (everything follows) if the calculus contains both implication plus falsity (negation) and recursion (fixpoint) combinators. To keep it consistent one has to omit one or limit both. One way to do it is to impose typing on terms so that type cycles are excluded.

Typed combinatory logic creates an isomorphism between the logics of combinators and conditionals (Curry–Howard isomorphism). In Lambek calculus (Lambek 1958, Moortgat 1988, Pentus 2007) type equations form a deductive system which supports inference of type assignments.

The difficult thing about classical combinators is that they apply Polish way left to right outside in. It is hard to predict the result from a given string of combinators, and equally hard to find the solutions for a given combinatory equation.

Strings of basic combinators quickly get impractically long.

**Categorical combinatory logic**

*Categorical combinatory logic* (Curien 1985, Diller 1988) is a combinatory logic based on cartesian closed categories. Its primitives are infix composition •, two-way identity **Id**, first and second projections **1st** and **2nd**, pairing, application and currying. A cartesian closed category is closed under pairing of morphisms dual to product so that the pair f,g maps to a*b the product of what f maps to a and g to b. The operator **apply** applies a morphism to an object, while **curry** curries a morphism of pairs into a morphism of morphisms. The following rules apply:

\[
\begin{align*}
  e^x &= c \text{ when } c \text{ is a constant} \\
  (x^o y)^o z &= x^o (y^o z) \\
  \text{Id}^o x &= x^o \text{Id} = x \\
  1^o (x,y) &= x \\
  2^o (x,y) &= y \\
  (x,y)^o z &= x^o z, y^o z \\
  \text{apply}^o((\text{curry } f),y) &= f^o (\text{Id},y) \\
  (\text{curry } f)^o g &= \text{curry } (f^o (g^o 1^o, 2^o))
\end{align*}
\]

For instance, the first clause connecting **apply** and **curry** reads ‘**apply** to **curry** of f and y equals f to its first argument and y’. Other equations saying the same thing are

\[
\begin{align*}
  \text{apply}^o(\text{curry } f) \circ 1^o, 2^o &= f \\
  \text{curry}(\text{apply}^o(g^o 1^o, 2^o)) &= g
\end{align*}
\]

Abbreviate \(\text{apply}^o\), by semicolon ;. Then we get more derived rules

\[
\begin{align*}
  (x;y)^o z &= (x^o z ; y^o z) \\
  (\text{curry } x) ; y &= x^o (\text{Id};y) \\
  (\text{curry } x^o y) ; z &= x^o y; z
\end{align*}
\]

The inverse of **curry** is known as **uncurry** (Gordon 1979). The main difference to combinatory logic is that the appearance of the product type **pair** alongside functional types. Pair combinators are something to keep an eye on in natural language. A candidate in natural languages is a symmetric predicate like meet which can be applied to a pair **A** and **B** meet **meet** (a and b) or curried into **A** meets **B** and **B** meets **A**. a (meet b) and b (meet a).

Categorical combinatory logic shows that combinatory logic can be carried out in terms of products or sums as well as arrows. Using sums and products leads to monoidal type combinatory calculus (flow algebra). One can also combine both, and have a calculus of combinators of all sorts.
Categorical combinatory logic is just one extension of combinators beyond the functional universe of lambda calculus. The type inventory has been extended from functional types to relational, product and sum types (Feferman 1975, Martin-Löf 1984, Lambeke 1988, van Benthem 1991, 1996).

Object oriented programming and abstract data types in general apply a similarly generalised category theoretic perspective on objects and their morphisms. Functional programming languages ML (Milner et al. 1997) or Haskell (Peyton Jones/Lester 1992) have a lot in common with the event calculus. Haskell (Hudak et al. 1999) implements both functional object oriented and imperative event oriented “world views” in a way which is quite compatible with mine.

**Flow algebra**


The unit object here is an $m$-$n$ relation interpreted as an event type of $m$ inputs and $n$ outputs. The calculus covers the combinatorics of composing such event types. It consists of a combination of an additive and a multiplicative calculus of relations. The additive calculus describes flowcharts, or flow of control in a decision graph. The multiplicative calculus describes connections, or flow of data through input-output ports in a connection graph. In linguistic terms: event structure and argument structure.

Think of event structure as a series of partial scenes, each with a number of participants. Control flow describes the temporal (or causal) succession of the scenes, and data flow mappings between participants in different scenes. (The scenes themselves may be complex event structures, so they may have distinct input and output ports.) Describing an event type involves describing which consecutive events it may consist of on the one hand, and how the participants of the successive events map on to one another, on the other hand. This is nothing but an alternative terminology for the natural language distinction between aspect and diathesis.

The additive calculus of flow algebra contains regular algebra. The multiplicative calculus is a monoidal product based counterpart of combinatory logic. Like combinatory logic, the algebra has operators for composition, identity, permutation, deletion, and copying, which allow defining arbitrary mappings between inputs and outputs. There are even operators for distribution, reduction (the dual of distribution) and feedback (fixpoint, or iteration). Action calculus (Milner 1995) replaces the combinators with an abstraction operator, analogous to lambda abstraction. The duality of control flow and data flow generates a natural mapping between object and event domains. In this morphism, states match with identity relations, cycles with cyclic relations (states are reflexive relations or cycles of length 1, symmetric relations are cycles of length 2) and open event types with transitive relations.

**Proofs**

Examples of event calculus theorems and their proofs follow.

1. Resultative is an open event type, i.e. $e/r.e\backslash r = e\backslash r$.

   Lemmas: $r = rr$ and $e = er = e/r$ and $< = <r = <r$, in virtue of $r$ and $<$ being open. Proof:

   \[
   \begin{align*}
   e\backslash r & e\backslash r \\
   &= r.e\backslash r, r.e\backslash r <r \\
   &= rr(r.e\backslash r) <r.e\backslash r <r(rr) \\
   &= r.e\backslash r <r <r.e\backslash r <r <r, r.e\backslash r <r, r.e\backslash r <r <r, r.e\backslash r <r <r \\
   &= e\backslash r \\
   \end{align*}
   \]

   Q.E.D.

4. Aspect inference:

   He was out and now he is in. He must have come in.

   $\neg in<now$ and $in<now$ entail $\neg in.in<now$.

   Proof: By compactness, $< = \neg(in \rho \neg in)$. The premises thus combine to $\neg(in \rho \neg in)^*(\neg in<now)$, which by rule 13 entails $\neg(in^*in)^*$. This, by openness, entails $\neg(in<now)$ which by the dual of 12 equals $\neg in.in<now$ which entails $\neg in<now$, equivalent to $\neg in.in<now$.

5. $pf+a$ is the series $(\neg aa)^*\neg a$.

   Proof: $pf+a = pf a \cup pf a \cup \ldots = \neg aa\neg a ? \cup (\neg aa\neg a ?) \cup (\neg aa\neg a ?) \cup \ldots = Q.E.D.$

6. Aspect inference

   He came in and he has not gone out since then. Ergo he is in.

   $\neg in . in<then<now$ and then $\neg(in \neg in<\neg)$ entail $in<now$.
Proof: By compactness, \( \neg(\in\neg \in\neg \in) \) equals \( \neg \in \neg \in \in\neg \) We have three cases: \( \in \in \in \neg \in \) which entails the conclusion, \( \in \in \in \neg \in \neg \) which contradicts the second premise, and \( \in \in \in \neg \in \neg \) which entails \( \in \in \neg \in \) i.e. \( \in \in \neg \in \). Since \( \neg \in \) is a simple state, this also entails the conclusion. Q.E.D.

7. \( a = a \in \neg a \in \neg a \in \neg a \) Proof: \( a = a \in \neg (a \in \neg a) = a' = a a' = a \in (a \in \neg a) \in \neg a \). Q.E.D.

8. \( (a \in \neg a)'' = (a \in \neg a)'' \) Proof: \( (a \in \neg a)'' = (a \in \neg a)'' \in \neg (a \in \neg a)'' \in \neg (a \in \neg a)'' = (a \in \neg a)'' \). Q.E.D.

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