[-ATR] HARMONY AND THE VOWEL INVENTORY OF SUMERIAN

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It has long been accepted that Sumerian exhibited some form of vowel harmony, and early descriptions of Sumerian vowel harmony (Poebel 1931; Kramer 1936) framed that harmony data in the context of a six-vowel inventory. While the arguments in favor of vowel harmony are now accepted, the expanded vowel inventory has largely been dismissed for the past seventy years. Instead, modern descriptions of the Sumerian vowel inventory are restricted to the four vowels that are visible through the filter of Akkadian.

After decades of neglect, Keetman (2005) reopened the discussion of the relationship between Sumerian vowel harmony and the language's vowel inventory. Although he is definitely on the right track, the solution he suggests, which requires two forms of vowel harmony to be operating simultaneously, is overly complicated. This paper shows how the choice of appropriate phonological features can simplify Keetman's analysis, and explain the data as the result of a single vowel-harmony process.

The goal of the paper is to reexamine the vowel harmony described by Poebel and Kramer, and situate it in a modern phonological framework. Contrastive and typological factors indicate that the observed vowel harmony behavior is best explained by a seven-vowel inventory. By examining Old Babylonian lexical texts and the Sumerian lexicon, we find additional support for a seven-vowel inventory. By drawing together the data from vowel harmony, from lexical texts, and from cross-linguistic universals, I conclude that Sumerian actually had a seven-vowel inventory.

I begin in section 1 by discussing existing arguments for an expanded vowel inventory that draw upon orthographic data. In section 2, I present the vowel harmony patterns that led Poebel and Kramer to propose their six-vowel inventory. In section 3, the core of the paper, I reframe the earlier analysis of vowel harmony in modern terms, and shows how a seven-vowel inventory is the most plausible one. Section 4 ties together the lexical and phonological evidence to provide additional support for a seven-vowel inventory.

1. Orthographic Evidence

Much of our knowledge of how Sumerian was actually pronounced comes from the lexical texts of the Old Babylonian period. Since the Old Babylonian scribes were no longer native speakers of Sumerian, they took extra care in representing the full phonology of the words being written. These lexical lists are invaluable to modern scholars because they spell out syllabic writings for Sumerian words whose pronunciation would otherwise be completely opaque.

Although lexical lists are vital to our understanding of Sumerian phonology, most of them come with two significant limitations. First, most of the exemplars available to us appear to have been exercises used as part of the scribal training process (Civil 1979), which means that they are not without errors. More fundamentally, the problem is that these lists represent the pronunciation of Sumerian as filtered through the Akkadian phonological system.

The limitations of the Akkadian inventory are particularly problematic for our reconstruction of the Sumerian vowel system. Since Akkadian has a system with four vowel-qualities (/a/, /e/, /i/, and /u/), any Sumerian vowels that cannot be represented within that system are hidden to us.

Scholars of Sumerian have tended to be extremely conservative when it comes to admitting new phonemes into the inventory (e.g., Black 1990). Hence, the most recent accounts of the Sumerian vowel system, such as Michalowski (2004) and Edzard (2003) have restricted themselves to the /a/, /e/, /i/, /u/ system, which can securely be supported by Akkadian.

Some scholars, notably Edzard (2003) have argued that Sumerian, like Akkadian, had a distinction in vowel length, but this view does not seem to have garnered much support. In any event, the existence of vowel length is orthogonal to the questions of vowel quality that are the focus of this paper.

1.1. Evidence from Lexical Texts

It has long been accepted that certain signs that shared a single phonetic value in Akkadian had multiple values in Sumerian, with the best example being the signs ⟨ga⟩ and ⟨ga_2⟩, which had Sumerian values of /ga/ and /g̃a/ respectively, but were both read as /ga/ in Akkadian. Just as ⟨ga⟩ and ⟨ga_2⟩ conceal two different consonants in Sumerian, it is possible that some of the apparently homophonous vowel graphemes might also conceal two different vowels. The strongest proponent for this theory was Lieberman (1977, 1979), who proposed that some of the graphemes read as /u/ in Akkadian properly had a reading of /o/ in Sumerian.

The evidence for Lieberman's theory comes largely from copies of the Old Babylonian lexical list *Ea*. In particular, Lieberman focused on early versions of the lexical list *Ea* from the city of Nippur. These early recensions consist of only two columns, with a grapheme in the right column and the corresponding pronunciation(s) in the left column. The practice in this lexical list was to make the pronunciation of a CV grapheme clearer by repeating the vowel. So for instance, the ⟨bi-e⟩ in line 17 told the scribe that the ⟨KU⟩ sign is to be read /be/ and not /bi/. Consider lines 10 and 11 of the fragment transcribed in (1), which clearly indicate that ⟨ku-u_2⟩ and ⟨ku-u_3⟩ represent two distinct pronunciations of the ⟨KU⟩ grapheme.

(1) A Fragment of the Lexical List *Proto-Ea* (Landsberger 1951, 1955; Civil 1979)

Line	Pronunciation	Sign
10	ku-u_3	KU
11	ku-u_2	KU
12	su_2-uš	KU
13	tu-uš	KU
15	su-uh_2	KU
16	ši-i	KU
17	be_2-e	KU
18	bi-id	KU
19	da-ab	KU
20	du-ur	KU
21	du-ru	KU
22	nu-u_2	KU
23	bu-u_2	KU
24	tu-ku-ul	KU

There are several similar examples in *Proto-Ea*, although not all of them are as clear-cut as the case of the ⟨KU⟩ grapheme. Throughout the lexical list there does appear to be a distinction being made between pronunciations that are indicated with the ⟨u_2⟩ grapheme and pronunciations that are indicated with the ⟨u⟩, ⟨u_3⟩, or ⟨u_4⟩ graphemes.[1] Lieberman claimed that ⟨u_2⟩ is being used to indicate /u/, while the other three graphemes are being used to indicate a pronunciation of /o/. These are summarized in Appendix A.

Supporting this position, Lieberman claimed that in Nippur Akkadian of this period it was also the practice to make a distinction between ⟨u_2⟩

1. Keetman (personal communication) notes that *Proto-Ea* also contains the sign ⟨u_8⟩. Keetman (2005) devotes considerable discussion to the possible phonetic value of ⟨u_8⟩, but the question remains outside the scope of this paper.

on the one hand and ⟨u⟩ or ⟨u_4⟩ on the other hand. Poebel (1939) had noted that when writing Akkadian, Nippur scribes of this period would use ⟨u_2⟩ for /i+u/ and /u+u/ contractions, and would use ⟨u⟩ or ⟨u_4⟩ for /a+u/ contractions. Note that in all cases, these contractions are phonemically a long /u:/, and not a diphthong; evidently though, there was an allophonic variation depending on the underlying origin of the /u:/, and this variation manifested itself in written Akkadian. The same scribal tradition that used ⟨u⟩ and ⟨u_4⟩ to distinguish an Akkadian allophone of /u/ used the same graphemes to render the Sumerian phoneme /o/ (Lieberman 1977).

Somewhat more controversial is the attempt by Bobrova and Militarëv (1989) to build upon Lieberman's work and extend the Sumerian vowel system even further. Bobrova and Militarëv made an analysis of spelling variations in the pronunciation guides provided in other lexical lists. So for example, in one lexical list the ⟨MIN⟩ grapheme is indicated with a pronunciation of ⟨mi-in⟩ while in another it is indicated as ⟨ma-an⟩, and they argued that this a:i variation is evidence for the existence of a front /ä/ phoneme. In similar fashion, they used u:i, i:e, and a:u variations to argue for the vowel system shown in (2).

(2) Extended Vowel Inventory for Sumerian (Bobrova and Militarëv 1989)

i, ü		u
	ə or ɨ	
e		o
	ä a	

Undercutting their analysis, however, is the fact that the spelling alternations in question were largely drawn from later texts that post-date the presumed extinction of spoken Sumerian. Moreover, their methodology depends on comparing pronunciation guides from different lexical texts, which could be subject to variation for reasons other than the attempt to render distinctions in vowel quality. While such an inventory cannot be ruled out, there does not appear to be sufficient evidence to support it. Lieberman is on somewhat more secure grounds, since the variations he observed are all within a single lexical text.

2. Vowel Harmony Data

When considering data from lexical lists, it must be remembered that, with the exception of a handful of early lists from Ebla, such lists date from the Old Babylonian period at the earliest. Since they were written by and for Akkadian-speaking scribes, they might well have been composed in a period when there were no longer any native speakers of Sumerian. Fortunately, there is other orthographic evidence that clearly dates from Sumerian texts written by Sumerian-speaking scribes. Specifically, there appear to be a fair number of orthographic patterns that can best be explained as a consequence of vowel harmony.

Within two-syllable stems, there appears to be a tendency towards having the same vowel in both syllables (Poebel 1923; Michalowski 2004). A typical example is the Sumerian word for "bronze," *zabar*. This appears to be a *Kulturwort* common to a number of languages in the region. In the neighboring Akkadian, the word is *siparru*, while in Elamite (southwestern Iran) the word is *zubar*. This suggests that vowel harmony operated on this word after it had been adopted into Sumerian, turning the high vowel of the first syllable into a low vowel. To date, no comprehensive study has been done on stem-internal vowel harmony in Sumerian, although a brief outline of some of the data will be provided in §4.2. Most of the attention, rather, has been devoted to studying vowel harmony in the Sumerian "verbal chain."

Sumerian is an agglutinative language, and verbal stems are generally accompanied by a number of prefixes and suffixes. For many decades scholars have noted that these affixes in the verbal chain tend to exhibit vowel changes depending on the stem to which they are attached.

The general structure of the Sumerian verb complex is shown in (3). The exact forms, functions, and ordering of these affixes has been the subject of much-heated debate among Sumerologists. However, since we are interested here

only in the phonological combinations that these affixes set up, all that is important here is the general rule that within each "slot," the affixes are mutually exclusive. A number of the affixes have allomorphs, which are indicated in (3) separated by slashes.

(3) Order of Elements in Sumerian Verbal Chain (Thomsen 1984; Michalowski 2004)

1. Mood	{ he-, nu-, ha-/he_2-/hu-, bara-, u-, na-, ga-, sa- }
2. Conjunction	{ inga- }
3. Conjugation	{ mu-/ma-, ba-/bi_2-/be_2-, i_3-/e-, al- }
4. Indirect object	{ a-, ra-, na-, me-, ne- }
5. Dimensional prefixes	{ da-, ši-/$še_3$-, ta-, ra-, ni-/ne-, i- }
6. Agreement prefixes	{ e-, n-, b- }
7. Verbal stem	
8. -ed suffix	{ -ed }
9. Agreement suffixes	{ -en, -enden, -enzen, -ene, -eš }
10. Nominalization suffix	{ -a }

Already in the first comprehensive study of Sumerian (Poebel 1923), a wide range of both regressive and progressive vowel harmony was identified in the verbal chain. Subsequent studies have found further instances of vowel harmony. Upon closer examination, it appears that the term "vowel harmony" is being applied rather broadly here, and that there are two somewhat different phenomena involved.

In the first type of vowel harmony, the vowel of the affix assimilates completely to the trigger vowel. So, for instance, the conjugation prefix *mu-* appears with the 2nd-person singular dative prefix *ra-* as ⟨ma-ra⟩; with the prefix *ni-* we get ⟨mi-ni⟩ (Poebel 1923). This type of harmony also operates progressively, as is the case of the verbal suffix *-ed*, which changes to *-ud* when following a verbal stem containing a /u/ vowel, producing a form like ⟨tum-ud-a⟩ rather than *⟨tum-ed-a⟩ (Poebel 1923; Thomsen 1984). While this phenomenon is interesting, it does not provide much insight towards reconstructing the vowel inventory.

2.1. Harmony in the Conjugation Prefixes -/e- and bi-/be- (Poebel 1931 and Kramer 1936)

The clearest type of vowel harmony is illustrated in Old Sumerian texts from southern Mesopotamia, particularly from the city state of Lagas. Early studies by Poebel (1931) and Kramer (1936) showed that the conjugation prefixes *i-* and *bi-* become *e-* and *be-*, respectively, whenever the verbal stem to which they are attached contains an /a/ vowel.

The conjugation prefix *i-* is ordinarily written as ⟨i_3⟩.[2] This in itself is rather curious because there is a very common ⟨i⟩ grapheme, but this particular morpheme is consistently written as ⟨i_3⟩ instead. It has been argued that the underlying form of the morpheme may actually be /ĩ/ (Thomsen 1984), but this is not widely accepted. Whatever the case, this [+nasal] feature does not appear to have any effect on the prefix's behavior with respect to vowel harmony.

Before stems with a /u/, /i/, or /e/ vowel, the prefix is written as ⟨i_3⟩. So we observe forms like ⟨i_3-de_2⟩, ⟨i_3-dirig⟩, ⟨i_3-du_3⟩, ⟨i_3-dug⟩, and ⟨i_3-gi_2⟩. However, before stems with an /a/ vowel we observe the prefix being written ⟨e⟩, as in ⟨e-ak⟩, ⟨e-ba⟩, ⟨e-bal⟩, and ⟨e-ğ̃al$_2$⟩. There are isolated exceptions (e.g., ⟨i_3-gaz⟩ appears once instead of the usual ⟨e-gaz⟩), but these form a tiny fraction of the corpus (Poebel 1931).

There is a similar patterning for the conjugation prefix bi-. Before stems with /u/ and /i/ vowels,

2. An anonymous reviewer has pointed out that the prefix is often written ⟨i⟩ in the Isin-Larsa and later periods. However, this is perfectly understandable, since it would reflect scribal practice after the period in which harmony was an active phenomenon in Sumerian.

the prefix is written as ⟨bi_2⟩; before stems with /a/ vowels it is written as ⟨be_2⟩. So we observe ⟨bi_2-du_3⟩ and ⟨bi_2-gi_4⟩ in contrast with ⟨be_2-ak⟩ and ⟨be_2-g̃ar⟩ (Kramer 1936).

The cooccurrence pattern for conjugation prefixes *i-* and *bi-* in the Early Dynastic texts from southern Mesopotamia is summarized in (4). A more detailed and complete presentation of this data is included as Appendix B. The data is also discussed in somewhat more detail by Keetman (2005).

(4) Co-occurrence of Conjugation Prefixes with Verb Stems

Stem vowel	With ⟨i_3⟩ or ⟨bi_2⟩	With ⟨e⟩ or ⟨be_2⟩
/a/		*ag̃*$_2$, *ak*, *ba*, *bal*(*a*), *bar*, *dab*$_5$, *gaz*, *g̃al*$_2$, *g̃ar*, *had*$_2$, *hal*, *la*$_2$, *nag*, *sa*$_6$, *sar*, *tag*, *tag*$_4$
/e/	*de*$_2$, *keš*$_2$, *se*$_3$(*g*/*k*), *se*$_{12}$, *te*/*ti*	*de*$_6$, *g̃en*, *me*, *šeš*$_2$/*šeš*$_4$
/i/	*bil*, *gi*$_4$, *gid*$_2$, *il*$_2$, *si*, *sig*$_7$, *til*, *zig*$_3$	
/u/	*du*$_3$, *du*$_8$, *du*$_{11}$, *dub*, *gub*, *gul*, *hug*, *ku*$_4$(*r*), *mu*$_7$, *su*, *su*$_3$, *su*$_8$, *šu*$_2$, *tu*$_5$, *tu*$_{17}$, *tuku*, *tuš*, *u*$_5$, *uru*$_4$, *us*$_2$	*ru*, *sur*, *ur*$_3$, *ur*$_4$

The stems with /a/ and /i/ are the most clear-cut. All the /a/ stems are written with the ⟨e⟩ or ⟨be_2⟩ versions of the prefixes, while all the /i/ stems are written with the ⟨i_3⟩ or ⟨bi_2⟩ versions. Poebel argues that this is evidence of vowel harmony: the "open" vowel /a/ in the stem causes the appearance of the "open" /e/ in the prefix. Before stems containing a "closed" vowel /i/, the underlying /i/ prefix is found.

In most cases, stems containing the vowels /e/ and /u/ are found with the /i/ forms of the prefix, but there are a number of verbs that unexpectedly take the /e/ prefix. For instance, Poebel notes that before the verbal stems ⟨g̃en⟩ and ⟨me-a⟩ the *i-* prefix is consistently written as ⟨e⟩, even though the stem vowel would lead us to expect a writing of ⟨i_3⟩. The solution he presented was to have two /e/-type vowels in the inventory. In addition to the ordinary "closed" /ē/[3] there is an "open" /ĕ/, which is the vowel that is found in the stems ⟨g̃en⟩ and ⟨me-a⟩.

In addition to noting stems written with an /e/-type vowel that take the wrong prefix, there are also stems written with a /u/-vowel that break the pattern of prefixes. Unexpectedly we see ⟨e-ur_4⟩ rather than *⟨i_3-ur_4⟩ and ⟨e-sur⟩ rather than *⟨i_3-sur⟩ (Poebel 1931). The same can be seen with the *bi-* prefix, where we see ⟨be_2-ru⟩ rather than ⟨bi_2-ru⟩ (Kramer 1936). The solution proposed by Poebel was that in addition to the "closed" /u/, there must an "open" equivalent /ŏ/.

The vowel inventory proposed by Poebel is shown in (5). With the addition of these two vowels to the four attested from Akkadian, there is a simple phonological explanation of why the conjugation prefixes are written with the ⟨i_3⟩ and ⟨bi_2⟩ graphemes before some verbs, and with the ⟨e⟩ and ⟨be_2⟩ prefixes before other verbs, namely that the choice of "open" or "closed" vowel in the prefix is determined by the vowel used in the stem.

(5) Vowel Inventory for Sumerian (Poebel 1931)

i		u	"closed"
ē			
ĕ	ŏ		"open"
a			

2.2. *Behavior before Other Prefixes*

In addition to the conjugation prefix, other prefixes can also be involved in the vowel harmony

3. Although Poebel distinguishes these vowels using diacritics normally associated with vowel length, it is clear from his discussion that this is merely a typographic convention, and that the distinction between /ĕ/ and /ē/ is definitely not one of vowel length.

process. For instance, the terminative-case prefix *ši-* can be written either ⟨ši⟩ or ⟨še$_3$⟩. Poebel noted that the choice of forms is conditioned by the vowel in the verbal stem, with *ši-* being written ⟨še$_3$⟩ before an "open" vowel. If the verb happens to start with the *i-* conjugation prefix, then the prefix will also harmonize with the stem vowel, so we observe forms like ⟨i$_3$-ši-ti⟩ and ⟨i$_3$-ši-um$_2$⟩, in contrast to ⟨e-še$_3$-ĝar⟩ and ⟨e-še$_3$-de$_6$⟩.

Poebel observed the same pattern for the prefixes *mi-* and *ni-*.[4] We find forms like ⟨i$_3$-mi-du$_3$⟩, ⟨i$_3$-ni-dug⟩, and ⟨i$_3$-ni-gi⟩, contrasting with forms like ⟨e-me-ed⟩, ⟨e-ne-ĝar⟩ and ⟨e-ne-la$_2$⟩. Once again, Poebel's division of the /e/-vowels into /ē/ and /ĕ/ provides a tidy explanation for the otherwise inexplicable difference in morphology between ⟨i$_3$-mi-e$_3$⟩ /imiē/ and ⟨e-me-šed⟩ /ĕmĕšĕd/.

The actual vowel that is governing the form of the prefix need not be part of the verbal stem. If there is a prefix containing /a/ intervening between the prefix and the stem, it is the /a/ that takes effect, regardless of the vowels in the stem. Hence with the prefixes *na-*, *da-*, *ta-*, and *ma-* we observe forms written with an initial ⟨e⟩ regardless of the stem vowel, such as ⟨e-na-de$_2$⟩, ⟨e-da-si$_{12}$⟩, ⟨e-ta-zi⟩, and ⟨e-ma-dur⟩ (Poebel 1931).

The third-person plural dative prefix *ne-* also triggers the ⟨e⟩ form of the prefix regardless of the stem vowels. This suggests that the prefix's underlying form must be /nĕ/ with an "open" vowel. If the underlying form had been /n/, we would have expected to see *⟨i$_3$-ne-si$_3$⟩, but we see ⟨e-ne-si$_3$⟩ instead.

3. Phonological Analysis

We are now in a position to consider which phonological features would explain the phenomena described here. We shall work from the assumption that harmony effects are a consequence of contrasts within the vowel inventory. Hence, it is necessary to divide up the vowel inventory using a contrastive feature hierarchy. Following Dresher (2003), we will build such a hierarchy using the Successive Division Algorithm, as described in §3.3.

The primary contrast in the vowel system seems to be between the vowels that Poebel referred to as "open" (/a/, /ĕ/, and /ŏ/) and the vowels that he referred to as "closed" (/i/, /ē/, and /u/). We could adopt Poebel's terminology and refer to the contrastive feature as being [±open] or [±low].

The choice of [±low] as the active feature in vowel harmony seems to have been the starting point for the analysis proposed by Keetman (2005). However, Keetman recognizes that the feature [±low] is not sufficient to account for all the vowel harmony patterning, particularly harmony within roots. Keetman proposes that a second type of harmony, involving the feature [±round], is simultaneously active in Sumerian. Under his analysis, the first type of harmony involves changes to the first formant, while the second rounding harmony involves the second formant.

However, as we will show, the type of vowel-harmony behavior found in Sumerian strongly resembles examples from other languages, where an apparent height harmony effect can best be described as an instance of tongue-root harmony. Such harmony does not necessarily involve the first and second formants, but nonetheless can account for all the vowel-harmony behavior, both within the verbal prefix chain and within roots.

If we are describing Poebel's closed /ē/ and open /ĕ/ in terms of tongue-root, we would say that /ē/ is [+ATR] (advanced tongue root) while /ĕ/ is [–ATR]. To use International Phonetic Alphabet (IPA) notation, Poebel's /ŏ/ would correspond to /ɛ/ while his /ē/ would correspond to IPA /e/. Since the vowels in the stems ⟨gen⟩ and ⟨me-a⟩ both triggered the *e-* prefix, the vowels must be the [–ATR] variant, so those stems would actually be /gɛn/ and /mɛa/.

Poebel gave no phonetic details of what /ŏ/ might be, but following our assumption that /ĕ/ is [–ATR], Poebel's // should correspond to a [–ATR] vowel such as /ɔ/ or possibly /ʊ/. Under this inter-

4. Care must be taken in identifying these forms. The prefixes *mi-* and *ni-* have allomorphs *me-* and *ne-*, which can potentially be confused with the dative-case prefixes *me-* and *ne-*. Fortunately, it is almost always clear from the context which prefix was intended.

pretation, the verbs written ⟨ur$_4$⟩, ⟨sur⟩, and ⟨ru⟩ would actually be /ɔr/, /sɔr/, and /rɔ/, respectively.

Using this [ATR] feature, the vowel harmony system arranges itself very neatly. The [–ATR] vowels (/a/, /ɛ/, and /ɔ/) coincide with the [–ATR] prefix forms ⟨e⟩ [ɛ] and ⟨be$_2$⟩ [bɛ]. The [+ATR] vowels (/i/, /e/, and /u/) coincide with the [+ATR] prefix forms ⟨i$_3$⟩ [i] and ⟨bi$_2$⟩ [bi]. Restating Poebel's inventory from (5) using this terminology, we get something like (6).

(6) Distribution of [ATR] Feature in Sumerian

i			u	[+ATR]	⟨i$_3$⟩, ⟨bi$_2$⟩
	e				
	ɛ		ɔ	[–ATR]	⟨e⟩, ⟨be$_2$⟩
		a			

Since we lack any access to the articulatory and acoustic details of Sumerian phonetics, we can only use the term [ATR] in the loosest of ways. That is, we have no way of knowing whether the Sumerian [ATR] feature was actually articulated using a tongue root or by adjusting the pharyngeal cavity in some other way. Casali (2003) notes that from an acoustic standpoint, [+ATR] and [–ATR] vowels cannot always be distinguished by their height (i.e., their first and second formant values). Descriptions of African languages often characterize [+ATR] vowels as "hollow," "deep," or "breathy," while [–ATR] vowels are "tight," "choked," "muffled," "bright," or "creaky." Whatever the articulatory or acoustic details, [ATR] is a convenient name for this feature, and is consistent with terminology used in describing other languages.

A natural question would be whether it is /i/ or /ɛ/, which is the underlying form of the conjugation prefix. That is, do we have an [–ATR] feature that is spreading from stem vowels /a/, /ɛ/, and /ɔ/ and converting /i/ into [ɛ]? Or is the active feature [+ATR] spreading from stems with /e/, /i/, and /u/ to convert an underlying /ɛ/ into [i]? The answer is given to us by the form of the third-person plural dative prefix *ne-*, which co-occurs with the ⟨e⟩ form of the conjugation prefix, so its underlying form must be /nɛ/. The vowel remains unchanged even in front of a stem with a [+ATR] vowel, as seen in ⟨e-ne-si$_3$⟩ [ɛnɛsi] and ⟨e-ne-gi$_4$⟩ [ɛnɛgi]. If the [+ATR] feature were spreading and converting /nɛ/ to /ne/, then we would expect to see *⟨i$_3$-ne-si$_3$⟩ [inesi] rather than ⟨e-ne-si$_3$⟩. Since this indicates that the /ɛ/ vowel is not subject to vowel harmony, then the conclusion is that the mutable underlying form must be /i/, and the spreading feature is [–ATR].

In terms of targets and triggers, the only target we have identified is /i/. This phoneme is the target both for the prefixes *i-* and *bi-*, but also for the prefixes *i-*, *mi-*, and *ni-*. In all cases, /i/ becomes [ɛ] under the influence of a following [–ATR] vowel.

As to whether the other two [+ATR] vowels, /u/ and /e/, are subject to vowel harmony, it is difficult to be certain. These vowels do appear in prefixes like *mu-* and *he-*, but these prefixes do not appear to be affected by the presence of a [–ATR] stem vowel. In any case, even if these prefixes did alternate, it might be difficult to tell: /mu/ would become [mɔ] but would still be written with the ⟨mu⟩ grapheme, while /he/ would become [hɛ], which would also still be written as ⟨he⟩ or ⟨he$_2$⟩.

Like *ne-*, the prefixes containing /a/ (*na-*, *da-*, *ta-*, and *ma-*) all retain their identity even when they precede stems containing an [+ATR] vowel. We have no prefixes containing a reconstructed /ɔ/ vowel, so it is impossible to say what might happen to it. However, in the absence of any evidence to the contrary, it seems safest to assume that /ɔ/ is also immune to the effects of vowel harmony. Again, this is consistent with the analysis that the active spreading feature is [–ATR] and not [+ATR].

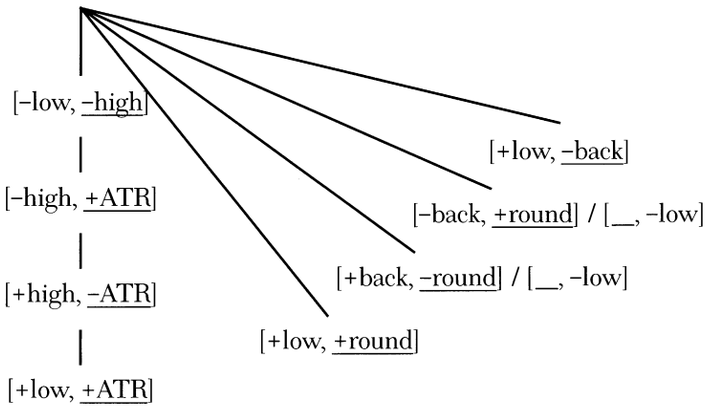
Many languages display [–ATR] harmony, including Khalka (Mongolian), and various Tungusic languages (van der Hulst and van de Weijer 1995). Chukchee (Chukotko-Kamchatkan), a language of eastern Siberia, also displays [–ATR] harmony, which is noteworthy since Krecher (1987) noted a range of structural traits shared by Chukchee and Sumerian. Of particular relevance to our study

of vowel inventories are Italian (Calabrese 1995) and various Niger-Congo and Nilo-Saharan languages (Casali 2003) which both display [–ATR] harmony similar to that of Sumerian.

3.1. A Typology of Vowel Inventories (Calabrese 1995)

The vowel inventory Poebel came up with consists of three vowels with the [–ATR] feature (/a/, /ɛ/, and /ɔ/), and three vowels with the [+ATR] feature (/i/, /e/, and /u/). Calabrese (1995) proposes a typology of vowel inventories that is based on a set of "marking statements," which are activated or deactivated in a given language. The deactivation of marking statements controls the complexity of phonemes that a given language will tolerate, and there are some universal restrictions on which sets of marking statements can be deactivated. The tree of marking statements is shown in (7). If a language deactivates a marking statement on a given branch, it must also deactivate the marking statements higher on this same branch. Under his analysis, a language that has not deactivated any marking statements at all would have the simplest possible inventory: /a/, /i/, /u/.

(7) Marking Statements for Vowel Systems (Calabrese 1995)



The inventory we have reconstructed for Sumerian most closely resembles an inventory that has deactivated the marking statements [–low, –high] and [–high, +ATR] on the leftmost branch of the tree. This is the sort of inventory found in Standard Italian, and is shown in (8).

It should be noted that the inventory in (8) includes an /o/, which Poebel did not reconstruct for Sumerian. This could represent a naturally occurring gap in the inventory, or it could just as easily represent yet another vowel that cannot be distinguished from /u/ due to the limitations of the writing system. In fact, given the evidence in §3.2 and §4.1, it seems likely that Sumerian did have an /o/ vowel distinct from both /ɔ/ and /u/.

(8) Inventory with [–low, –high] and [–high, +ATR] Deactivated (Calabrese 1995)

	i	e	ɛ	a	ɔ	o	u
high	+	–	–	–	–	–	+
low	–	–	–	+	–	–	–
back	–	–	–	+	+	+	+
round	–	–	–	–	+	+	+
ATR	+	+	–	–	–	+	+

3.2. [*ATR*] *Harmony and Vowel Inventories (Casali 2003)*

Fortunately for our analysis of the interaction between vowel harmony and vowel inventories, Casali (2003) has done an extensive cross-linguistic survey of [ATR] harmony in languages of the Niger-Congo and Nilo-Saharan families.

According to Casali (2003), there is an ongoing debate in the field between those who feel that only [+ATR] can be the active feature in vowel harmony (what Casali calls "Universal [+ATR] Dominance" theories) and those who feel that either [+ATR] or [-ATR] can be the active feature (the "Variable [ATR] Dominance" theories). Casali is very strongly in the Variable [ATR] Dominance camp, and the main goal of his paper is to show that not only is [-ATR] dominance a possibility, it is in fact very common in languages with certain types of vowel inventories.

As it turns out, the presence of [-ATR] spreading is correlated with certain types of vowel inventories. Casali divides inventories into three classes, as shown in (9). By our analysis, Sumerian should fall into the 4Ht(M) class. In Casali's classification, "4Ht" means that a vowel inventory has four different heights, while (M) indicates that the [ATR] feature is contrastive only for mid vowels.

(9) Vowel Inventories with Contrastive [ATR] (Casali 2003)

5Ht			4Ht(M)			4Ht(H)		
i		u	i		u	i		u
ɪ		ʊ				ɪ		ʊ
e	(ə)	o	e	(ə)	o		(ə)	
ɛ		ɔ	ɛ		ɔ	ɛ		ɔ
	ɑ			ɑ			ɑ	

For the purposes of his discussion, Casali ignores front/back asymmetries where there is a gap in the inventory of either front or back vowels. He does note however that inventories with a missing front vowel are more common than inventories with a missing back vowel. This suggests that the inventory proposed by Poebel (1931), lacking the /o/ vowel, is not particularly common.

A search of the UCLA Phonetic Segment Inventory Database (Maddieson 1984) suggests that Poebel's inventory is actually quite rare. Of the 317 languages listed in UPSID, there are 37 that have a contrast in the mid vowels and thus fall into Casali's 4Ht(M) category. The tendency towards symmetry is strong, because of those 37 languages; only six have asymmetrical vowel inventories. Furthermore, of those six, four are missing one of the mid-front vowels, and two[5] are missing one of the mid-back vowels. Of the two UPSID languages which are missing one of their mid-back vowels, in both cases the missing vowel appears to be /ɔ/ rather than /o/.[6] So while it is certainly possible that Sumerian has the six-vowel inventory proposed by Poebel, a full seven-vowel inventory seems more likely.

Casali's survey of over one hundred Niger-Congo and Nilo-Saharan languages indicates that languages with a 4Ht(M) inventory tend to have [-ATR] as the active feature in vowel harmony. In this regard, Sumerian agrees with Casali's observation.

Casali classifies the environments in which [ATR] harmony can manifest itself into six different categories, as shown in the columns of (10). Languages with a 4Ht(M) inventory tend to display the weaker forms of assimilation, but not the stronger forms. Once again, Sumerian behaves like a very typical 4Ht(M) language. In particular, the type of assimilation displayed by the Sumerian conjugation prefixes falls under Casali's category of "weak assimilatory [-ATR] dominance."

5. In fact, it may turn out that there is only a single language, Washkuk (Sepik-Ramu), which is missing a mid-back vowel and fits Poebel's pattern. The other UPSID language that is missing a mid-back vowel is Angas (Chadic), but Burkett (1973) indicates that Angas actually has a symmetrical 4Ht(M) inventory.

6. Note however that the classification may not be entirely accurate. When a language has only a single mid-back vowel, there seems to be a tendency to call it "o" rather than specifying it more precisely (Maddieson 1984).

Allophonic [-ATR] dominance refers to cases where an underlying [+ATR] vowel such as /i/ or /u/ has a [-ATR] allophone, such as [ɪ] or [ʊ]. If such allophones did exist in Sumerian, they do not appear to be distinguished in the writing system. However, I argue in §3.3 that the allophones [ɪ] and [ʊ] are not present in Sumerian.

Coalescent [-ATR] dominance would occur when adjacent [+ATR] and [-ATR] vowels fuse to form a single vowel. If [-ATR] is dominant, we might expect to find the fused vowel emerging as [-ATR]. However, there is no evidence that this sort of coalescence occurs in Sumerian.

(10) Sumerian Harmony in Various Environments

Strong assimilatory dominance			Allophonic [-ATR] dominance	Coalescent [-ATR] dominance	Weak assimilatory [-ATR] dominance
[-ATR] spread across word boundaries	[-ATR] spread in compounds	[-ATR] spread from dominant affixes			
no	no	no	no	no	no

Casali claims that the strong assimilatory dominance is unlikely to be found in 4Ht(M) inventories. This may have to do with strong assimilatory dominance only being necessary because the perceptual distinctions between the [+ATR] vowels (/i/ and /u/) and their [-ATR] counterparts (/ɪ/ and /ʊ/) are particularly subtle. In a 4Ht(M) system, the perceptual distinctions between the [+ATR] vowels (/e/ and /o/) and their [-ATR] equivalents (/ɛ/ and /ɔ/) are easier to make, so strong assimilation is not necessary.

As expected from Casali's analysis, there is no evidence that Sumerian displays any sort of strong assimilatory dominance. There is no indication that [-ATR] spreads across word boundaries or between elements of a compound. Although there are affixes that have a [-ATR] vowel, such as the genitive case suffix *-ak* and the nominalizing suffix *-a*, these do not appear to influence the quality of other vowels in the stem to which they are affixed.

On the whole, Sumerian behaves like a very typical 4Ht(M) language. In line with Casali's analysis, the language displays [-ATR] dominance rather than [+ATR] dominance. And also in accordance with Casali, Sumerian displays only weak assimilatory [-ATR] dominance.

3.3. Application of Successive Division Algorithm (Dresher 2003)

The notion that contrasts within a phonological system are organized hierarchically has a long history, dating back at least to Jakobson and Halle (1956). The phonemic inventory is organized on the basis of contrastive features, which are specified in a hierarchical fashion. One particular contrast is deemed to be the most fundamental one within the system and that feature determines the initial binary division with the system. Subsequent contrasts within the hierarchy may only be valid for a particular value of a preceding feature. So for instance, if [back] is above [round] in the contrastive hierarchy, [back] is said to have scope over [round] and we would expect to find that [round] is only contrastive for a particular value of [back]. This concept is developed further in the Successive Division Algorithm (Dresher 2003; Dresher and Zhang 2004), as summarized in (11).

(11) Successive Division Algorithm (Dresher and Zhang 2004)

a. In the initial state, all sounds are assumed to be variants of a single phoneme.

b. If the set is found to have more than one phoneme, a binary distinction is made on the basis of one of the universal set of distinctive features; this cut divides the inventory into a marked set and an unmarked set.

The selected feature is contrastive for all members of these sets.

c. Repeat step (b) in each set with the next feature in the hierarchy, dividing each remain-

ing set until all distinctive sounds have been differentiated.

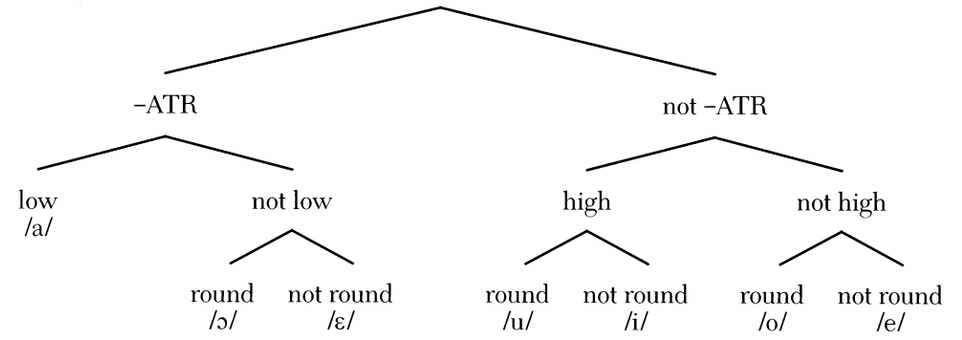
d. If a feature has not been designated as contrastive for a phoneme, then it is redundant for that phoneme.

The task then is to refer back to the inventory in (8), and determine which features have scope over which other features. The harmony process involves /a/ as a trigger vowel and /i/ as a target vowel, which indicates that [ATR] must be contrastive for both [low] and [high] vowels. This suggests that, in Sumerian, the [ATR] contrast is more fundamental than either of the height contrasts, and the application of the Successive Division Algorithm should start with a division on the basis of [ATR]. If we were to place either [high] or [low] for the initial division, then the algorithm would result in some vowels not being contrastive for [ATR] when they should be.

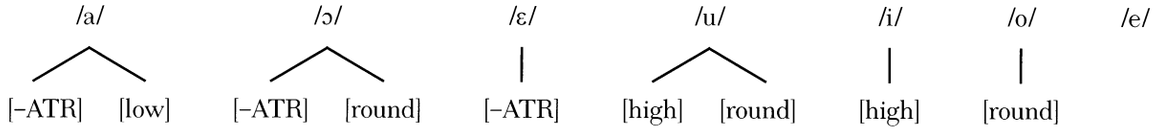
Since [-ATR] is the active feature in spreading, we will take that as the marked value. Rather than saying that the vowels /i/, /e/, and /u/ are [+ATR], we will instead describe them as simply lacking the [-ATR] feature.

The second iteration of the algorithm involves splitting the [-ATR] vowels according to the [low] feature. Similarly, the vowels that lack [-ATR] are split according to the [high] feature. After making divisions on the basis of [-ATR], [low], and [high], the next thing to determine is whether to divide on the basis of [back] or [round]. As it turns out, either choice produces the same results. We will arbitrarily choose the relevant feature as [round], but we could have just as easily called it [back] or [labial].

(12) Application of Successive Division Algorithm



(13) Feature configurations produced by (12)



Under this model, the vowel harmony behavior observed in Sumerian can be seen to be caused by the spreading of the [-ATR] feature. Adding a [-ATR] node to /e/ produces /ɛ/, but the writing system makes it impossible to distinguish the two vowels. Similarly, spreading [-ATR] to an /o/ vowel produces /ɔ/, but once again such a change is obscured by the writing system.

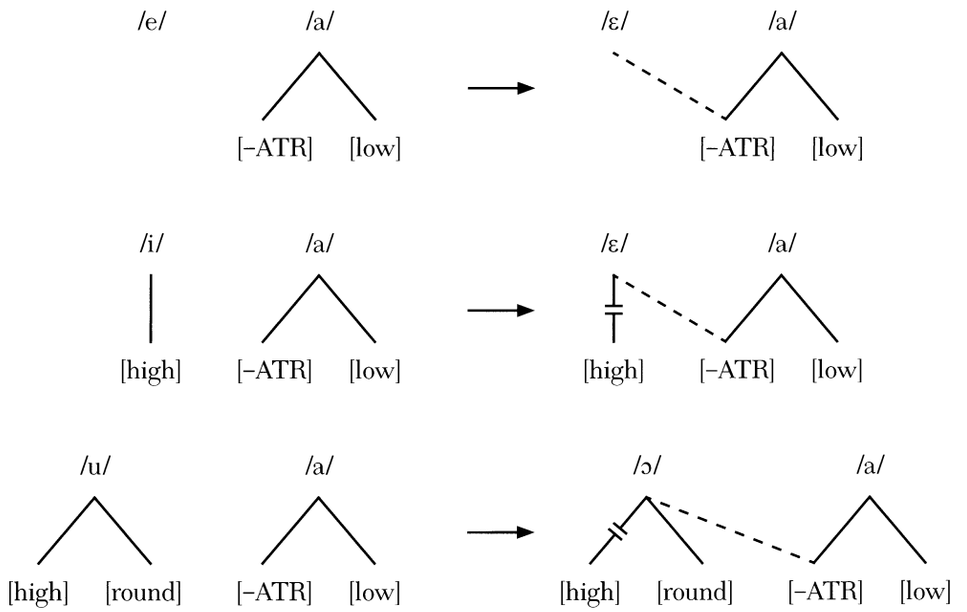
The one change that is clearly visible through the orthography is what happens when a [-ATR] node is added to an /i/ vowel. There is no vowel in the inventory that has both [high] and [-ATR] nodes. Referring back to Calabrese's tree of marking statements shown in (7), recall that we argued that Sumerian only deactivated the first two statements on the left branch (i.e., [-low, -high] and [-high, +ATR]). The marking statement [+high, -ATR] is still active in Sumerian, so a node containing [high] and [-ATR] will need to be repaired. The simplest repair process is simply to

delink the [high] node, leaving only a bare [–ATR] node (i.e., an /ɛ/).

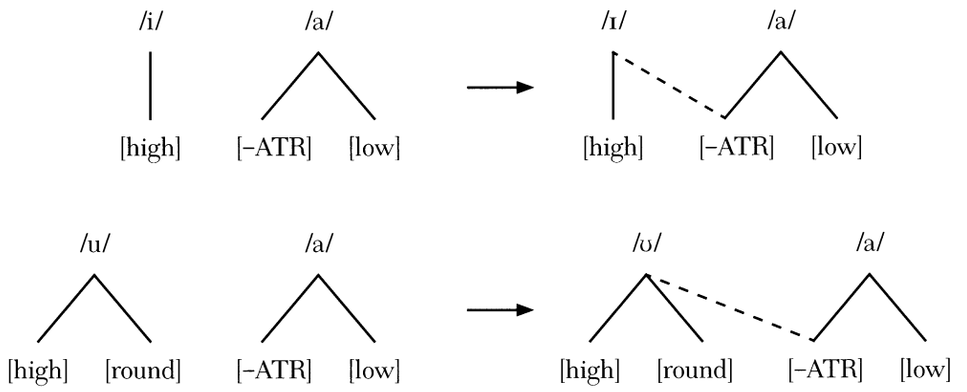
The same sort of process must occur when a [–ATR] feature spreads onto a /u/ vowel, producing a configuration that has [high], [round], and [–ATR] nodes. Again, the [high] and [–ATR] features violate Calabrese's marking statements, and a repair must be made, removing the [high] node to produce /ɔ/.

As it turns out, this is exactly the sort of repair process that Calabrese (1995) describes as taking place in Italian dialects such as northern Salentino and southern Umbro. In those dialects the [–ATR] feature spreads to an /i/ vowel, creating an illegal configuration, which is repaired by delinking the [high] node, producing an /ɛ/. The various assimilation processes are summarized in (14).

(14) Spreading of [–ATR] in Sumerian



(15) Allophonic [–ATR] harmony (not found in Sumerian)



Note that if these repair processes did not take place, then we would expect to observe the /i+a/ and /u+a/ assimilation to behave as shown in (15). This would represent the allophonic [–ATR] dominance described by Casali (2003). However, if this were the case, the conjugation prefix for a verb like *ak* "to make" would be pronounced [ɪak], and we would no longer have a justification for the spelling ⟨e-ak⟩. It is only by postulating a repair process that deletes the [high] feature that we can account for the ⟨e⟩ and ⟨be_2⟩ forms of the prefixes.

Akkadian scribes would not have had the vowels /ɛ/, /o/, or /ɔ/ in their inventories. The simplest way for them to adapt Sumerian vowels would be to map all back round vowels onto /u/ and all mid-front vowels onto /e/. This is summarized in (16).

(16) Adaptations of Sumerian vowels into Akkadian

Sumerian	Akkadian
i	i
e	e
ɛ	
a	a
o	u
ɔ	
u	

4. Further Evidence for the Vowel Inventory

The two arguments in favor of expanding the vowel inventory have so far followed separate paths. On the one hand, Lieberman (1977, 1979) and Bobrova and Militarëv (1989) have argued that orthographic data suggests the existence of vowels beyond the Akkadian /a/, /e/, /i/, /u/. In a parallel but separate approach, Poebel (1931) and Kramer (1936) have argued that vowel harmony also suggests the existence of an expanded vowel inventory.

Lieberman (1979) gives credit to Poebel for broaching the idea of an /o/ vowel in Sumerian, but he fails to connect his findings to Poebel's. Moreover, he suggests that Poebel later gave up on arguing for the existence of an /ɛ/ vowel.[7] While the /ɛ/ vowel is not important to Lieberman's orthographic studies, it is crucial for accounting for vowel harmony. Similarly, the /ɔ/ vowel suggested by the vowel harmony data is not seen by Lieberman as being distinct from the /o/ vowel.

4.1. Correlating Orthography and Harmony

Unfortunately for comparing the orthographic data from *Proto-Ea* with the harmony data from the conjugation prefixes, only a handful of the entries in *Proto-Ea* can unequivocally be identified as verbs. Of those verbs, only a few of those are forms that may contain the elusive /o/ vowel. And of those verbs with a possible /o/ vowel, only five are attested in the Early Dynastic texts from southern Mesopotamia with the relevant conjugation prefixes. These are summarized in (17).

Referring back to (4), we note that there are four verbs with apparent /u/ vowels, which must be /ɔ/ since they appear with the ⟨e⟩ and ⟨be_2⟩ prefixes: ru, sur, ur_3, and ur_4. Of these, ru and sur are found in *Proto-Ea* with orthographies that plausibly represent an /ɔ/ vowel. Line 736′ of *Proto-Ea*, containing the ⟨UR_3⟩ sign, is found on only one tablet, and the pronunciation column is too damaged to read. Line 872, containing the ⟨UR_4⟩ sign, gives only ⟨ur_2⟩ as the pronunciation, which provides no indication of whether an /ɔ/ vowel might or might not be present. Nonetheless, it is reassuring that the *Proto-Ea* data at least does not contradict the existence of those /ɔ/ vowels that are suggested by the vowel harmony behavior.

7. Apparently Poebel's change in position was due to the recognition that the ⟨deb_2⟩ sign also had a value of ⟨dab_5⟩. The existence of forms like ⟨e-deb_2⟩ had been the initial motivation for Poebel's arguments in favor of an /ĕ/ (or /ɛ/) vowel. However, there are several other verbs, such as ĝen, me, and de_6, which also co-occur with the *e-* form of the prefix, and hence provide evidence for /ɛ/.

(17) Correlating *Proto-Ea* /o/ vowels with vowel harmony data

Verb	Gloss	Prefix forms				Reconstructed phonology
		i_3	bi_2	e	be_2	
u_5	to ride	4				/o/
su_3	to be empty, to drown	29				/so/
uru_4	to sow, to cultivate	*1*				/oru/
ru	to lay down				3	/rɔ/
sur	to produce a fluid			1		/sɔr/

However, the vowel-harmony data do point towards the existence of both /o/ and /ɔ/. If, as Lieberman had suggested, there is only a single /o/-type vowel, then it is hard to explain why u_5 and uru_4 are written with the ⟨i_3⟩ prefix, while sur and ru are written with the ⟨e⟩ and ⟨be_2⟩ prefixes. The existence of a distinct /ɔ/ and /o/ vowels, one with and one without the spreadable [–ATR] feature, provides the necessary explanation for this difference.

It would have been useful if the lexical lists contained similar orthographic evidence supporting the /e/ vs. /ɛ/ distinction in Sumerian. However, such a distinction is not to be found in *Proto-Ea*, which is the earliest such list. It has to be remembered that the Sumerian writing system was not rigorous in distinguishing even between /e/ and /i/; it is hardly surprising that the much subtler distinction between /e/ and /ɛ/ is not represented at all.

Evidence from the Lexicon

While evidence for the expanded vowel inventory has drawn on vowel harmony in the prefix chain, it has also been noted that vowel harmony seems to be present elsewhere in the language. In particular, Michalowski (2004) notes a tendency for both vowels of a two-syllable word to harmonize. While a full study of the harmony within the Sumerian lexicon is beyond the scope of this paper, it is worth presenting some of the more relevant observations.

The electronic version of the Pennsylvanian Sumerian Dictionary (Sjöberg, Leichty, and Tinney 2004) lists 4336 lexical entries. These can be broken down as shown in (18). It should be cautioned that this is based on a cursory survey of the contents of the *PSD*. A more exhaustive study should be able to reduce the residue of unexplained violations of vowel harmony further.[8]

There is an interesting class of compound verbs that refer to making noise of various sorts. These uniformly violate regressive vowel harmony, typically consisting of a syllable with an /i/ or /u/ vowel followed by the same syllable with an /a/ vowel. Examples include *zikzak*... *za*, *pudpad*... *za*, *wuwa*... *za*, and in a more extended template, *dubuldabal*... *za* (Black 2003). Evidently there is some onomatopoeic factor here, but it is telling that this is expressed as a violation of the normal constraints on vowel harmony.

In accordance with Casali (2003), Sumerian should not display strong assimilatory [–ATR] dominance in compounds. That is to say, there is no reason to consider a form such as *niĝsaga* "goodness" (from *niĝ* [derivational morpheme] + *sag*, "to please") to be a violation of the rules of vowel harmony within Sumerian.

8. An anonymous reviewer has suggested that many apparent CVCVC and CVCV words in Sumerian may actually represent an attempt to render consonant clusters (/ccvc/ and /ccv/ respectively). He also suggests that a large number of CVCVC words in Sumerian are Semitic loanwords. Either of these factors may help to reduce further the residue of words that appear to be violating vowel harmony.

(18) Breakdown of Harmony within the Pennsylvania Sumerian Dictionary

<table>
<tr><td rowspan="8">4336 total entries</td><td colspan="3">1190 single-syllable words</td></tr>
<tr><td rowspan="7">3146 multi-syllable words</td><td colspan="2">155 with no establed reading</td></tr>
<tr><td colspan="2">2275 unambiguously obey vowel-harmony rules</td></tr>
<tr><td rowspan="6">871 contain an /e-a/, /i-a/, or /u-a/ sequence that may violate vowel harmony rules</td><td>36 appear to deliberately violate harmony for onomatopoeic reasons</td></tr>
<tr><td>335 can be analyzed as compounds</td></tr>
<tr><td>97 appear to have a final /a/ that originated as a suffix (e.g., genitive case -ak)</td></tr>
<tr><td>at least 19 appear to be loanwords from Akkadian or Hurrian</td></tr>
<tr><td>209 have an orthography where it is possible that an apparent /u/ is actually an /ɔ/ or an apparent /e/ is actually an /ɛ/</td></tr>
<tr><td>175 lack an obvious explanation</td></tr>
</table>

Similarly, Casali would predict that Sumerian suffixes should not be dominant. That is, a [–ATR] suffix should fail to spread [–ATR] to the stem. This is the case with the genitive case suffix *-ak*, as in *lu inimak* "witness" (from *lu* "person" + *inim* "word" + genitive *-ak*).

In many cases, it may be productive to reanalyze the reconstructed pronunciation to see whether an apparent /u/ or /e/ might actually conceal an /ɔ/ or an /ɛ/. That is to say that *guza* "chair" might actually be pronounced /gɔza/, and *engar* "farmer" might actually be /ɛngar/.

There does remain a residue of multi-syllable words that appear to disobey the rules of vowel harmony. However, this fraction is relatively small, only 176 out of the 4336 total words, or 4.1 percent of the total. These words, such as *nitah*, "male," and *sipad*, "shepherd," are difficult to analyze as anything other than an unequivocal harmony violation. The existence of such words, which clearly violate the phonological rules of Sumerian, has been used as evidence for a proposed pre-Sumerian substrate language, although the existence of such a substrate has strongly been challenged (Rubio 1999).

5. Conclusions

In this manner, Sumerian behaves in a fashion identical to modern-day languages that display tongue-root harmony. The patterns of weak assimilatory [–ATR] dominance and the 4Ht(M) inventory fit perfectly with the model described by Casali. While it is impossible to state unequivocally that the contrastive feature in Sumerian was phonetically realized as [–ATR], from a phonological standpoint, it acts just as if it really were [–ATR].

By correlating the data from lexical lists and the vowel harmony behavior, we see that Poebel's six-vowel inventory is inadequate for explaining the observed data. An additional /o/ vowel is required to explain the apparent discrepancies. Such an /o/ vowel produces a symmetrical seven-vowel inventory, which accords nicely with Calabrese's system of marking statements. In addition, this seven-vowel inventory appears far more common cross-linguistically than the asymmetrical inventory hypothesized by Poebel.

Although the feature model proposed here is necessarily speculative, it explains the observed data much better than the generally accepted four-vowel system that is visible to us through the filter of Akkadian.

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Appendix A: Possible /o/ orthographies in *Proto-Ea* (Landsberger 1951, 1955; Civil 1979)

Line	Pronunciation	Sign	Gloss
10	ku-u_3, ku-u_2	KU	ku "to place"[a]
38	u_2-mu-uh_2, u_3-mu-uh_2, u_4-mu-uh_2	LAGAB×U+A	umah "blow"
63	u_2-du, u_3-du, u_4-du	LU	udu "sheep"
66	mu-u_2, mu-u_4	TUG_2	mu_4 "to get dressed"
67	tu-u_2, tu-u_4	TUG_2	tug_2 "textile, garment"
69	u_2-mu-uš, u_3-mu-uš, u_4-mu-uš	TUG_2	umuš "sagacity"
76	u_2-ku, u_3-ku, u_4-ku	LAL_2.DU	ukur "poor"
77	u_2-šu-ur, u_3-šu-ur, u_4-šu-ur	LAL_2.SAR	usar "neighbor"
79	la-u_4, la-u_2, la-u_3	LAL_2.KAK	la'u "arrears"
94	mu-u_4, mu-u_2	NI	mu_5 "good"
112	u_4	U	u "hole"
113	šu-u_2, šu-u, šu-u_4	U	$šu_4$ "red"
121	šu-u_2, šu-u_4	SU_2	$šus_2$/$šu_2$ "to cover"
128	u_3, u_4	HU.SI	u_5 "to ride, mount"
145	u_4-ri	URI	uri "a vessel" xx
151	u_3	UD	u_4/ud "day"
164	su_2-u_2, su-u, su-u_3	LAGAR×SE	sur/su_7 "threshing floor; to produce a fluid"
172	mu-u, mu-u_4	MU	mu "name, year"[b]
190	u_2-ru-da, u_4-ru-da,	URUDU	uruda/urudu "copper"
230	u_4	U_2	u_2 "plant(s)"
310	u_2-gu, u_2-gu_2, u_4-gu_2	U.KA	ugu "skull"
346	u_3-gu-ur, u_4-gur	U.GUR	ugur "sword"
362	u_3-lu-ud, u_2-lu-ud	DUG	lud/ulud "a cup, bowl"
368	du-u_4	HI	dub_3 "knee" or dug_3/du_{10} "good"
374	u_4-ma-an	AH	uman "insect(s), bug(s)"
408	u_2, u_4	IGI.DIB	u_3 "sleep"
416a	u_4-ru	EN	urun/uru_{16} "to be strong, exalted"
476	su_2-u_2, su_2-u	SUD	sud/su_3 "to be empty, to drown"
497	du-u_2, du-u	DU	du "to go (sing.)"
512	su-u_2, su-u_4, su_4-u_2, su-u	DU DU	sub_2 "to go (pl.)", sug_2 "to stand (pl.)"
522	u_4-ru	APIN	uru_4 "to sow, to cultivate"
539	u_4-ru	URU	urum/uru_{11}
540	u_4-ru	URU×A	uru_{18} "flood"
541	u_4-ru	URU×UD	uru_2 "city"
575	u_4	PIRIG×UD	ug_x "light
594	u_4-ra-aš	IB	uraš "earth"

a. In those later tablets that provide an Akkadian gloss, the pronunciation column contains ⟨ku-u_2⟩, so it is likely that the meaning "to place" is properly associated with line 11 ⟨ku-u_2⟩ and not with line 10 ⟨ku-u_3⟩.

b. Line 171 has a pronunciation of ⟨mu-u_2⟩ for the ⟨MU⟩ sign, suggesting that the sign had two different pronunciations (/mu/ and /mɔ/ by our reconstruction). However, there are no surviving tablets with an Akkadian gloss for this sign, so it is not clear whether *mu* "year" and *mu* "name" were pronounced the same, or differently.

597	ru-u_3, ru-u_2	RU	ru "to lay down"
619	du-u_4, tu-u_4	TUK	du_{12} "to take"
669	tu-u_2, tu-u_4	IM	tu_{15} "wind"
671	ku-u_2	MI	ku_{10} (in ku_{10}-ku_{10}, "black")
766	u_4-un	EZEN×KAS	un_3 "to arise, to be high"
772	u_4-di-ni-im, u_4-di-nim	EZEN×SIG_7	udnim, a place name
774	u_3-ud-nim	[EZEN×SIG_7(?)]	udnim, a place name
830	u_3-bur	DAG.$KISIM_5$×GA	ubur "breast"

Appendix B: Co-occurrence Data for Conjugation Prefixes

The following table represents a synthesis of data from Poebel (1931), Kramer (1936), Bauer (1967), the Royal Inscriptions of Mesopotamia (Frayne, forthcoming), and the Cuneiform Digital Library Initiative (Englund and Damerow 2000–). Verbs that tend to co-occur with ⟨i_3⟩ and ⟨bi_2⟩ are listed first, followed by verbs that tend to cooccur with ⟨e⟩ and ⟨be_2⟩.

Data is drawn from all available Early Dynastic texts from southern Mesopotamia, chiefly from the city-state of Lagaš.

⟨i_3⟩	⟨bi_2⟩	⟨e⟩	⟨be_2⟩	Stem
1				bil "burn"
5				$bu_×$(r) "to tear out"
13		1		de_2 "pour"
11	11		3	du_3 "build"
120	1			du_8 "open, loosen"
	3			dug_4/du_{11} "speak, talk"
2	1			dub "heap up"
				durun "sit (pl.)"
5				$\tilde{g}i_4$ "return"
4				gid_2 "be long, measure out"
31	1			gu_7 "eat"
30				gub "stand"
5				gul "destroy"
1				hu$\tilde{g}$ "hire, rent"
5				il_2 "lift, carry"
12		1		kes_2 "bind"
188				ku_4(r) "enter"
	1			mu_7 "make noise"
17	3		1	se_3(g/k) "place"
6		2		se_{12} "dwell"
2				si "be full, fill"
				sig_7 "be pleasant"
4				su "replace"

29				su_3 “drown”
2				su_8(g) “stand”
5	24			$šu_2$ “cover, overwhelm”
24				te/ti “approach”
1				til “finish, cease, perish”
1				tu_5 “bathe, wash”
3				tu_{17}
35		5[a]		tuku “have”
19				tuš “sit, dwell”
4				u_5 “ride, mount”
1				uru_4 “plough”
13	3			us_2 “follow, join, reach”
1	1			zig_3 “rise, stand up”
1		1		ha-lam “ruin, destroy”[b]
1	2	2		šed/šid “count, recite”
1		5		$aĝ_2$ “measure”
2	1	63	11	ak “make, do”
		6		ba “give”
8[c]		14		bal(a) “cross, transfer”
		4		bar “open, split”
2		57		dab_5 “seize, catch”
1		2		de_6 “bring”
1		4		gaz “slaughter, kill”
1		14		$ĝal_2$ “be (somewhere)”
		17		ĝar “place”
		14		ĝen “go, come”
		1		had_2 “dry”
		3		hal “deal out, distribute”
		9		la_2 “carry, hang, weigh”
		5		me “be”
1		3		naĝ “drink”
			3	a . . . ru “dedicate”
		1		sag_9 “to be good”

a. All five of these exceptions come from a single tablet, *RTC* 76.

b. On the strength of the form ⟨i_3-ha-lam⟩, Poebel (1931) reads the ⟨HA⟩ sign as ⟨ku_6⟩. The ⟨ku_6⟩ value of this sign is attested in *Proto-Ea*, so such a reading is not unreasonable. In Poebel's account, the variation in conjugation prefixes then becomes a case of one scribe pronouncing the verb as [ekɔlam] and another scribe pronouncing it as [ikulam]. This seems like a lot to infer on the strength of a single variation in form.

c. Seven of these exceptions come from a single inscription, the Stele of The Vultures of Eannatum. Other than this verb, the Stele is quite consistent in representing vowel harmony in conjugation prefixes. To account for this, Poebel (1931) argued for a reading of ⟨bul_3⟩ for the ⟨BAL⟩ sign, but such a value is not attested until much later. *Proto-Ea* lists only the pronunciation ⟨ba-la⟩ for the ⟨BAL⟩ sign.

	19		sar “write”
	1		sur “produce a fluid”
1	9		$šeš_2$/ $šeš_4$ “anoint”
	22	36	tag “touch”
		1	du_{13} “leave, divorce”
	17		ur_3 “drag”
1	9		ur_4 “pluck, collect, harvest”