

Research Article

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Algol as Horus in the Cairo Calendar: the possible means and the motives of the observations

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Abstract: An ancient Egyptian Calendar of Lucky and Unlucky Days, the Cairo Calendar (CC), assigns luck with the period of 2.850 days. Previous astronomical, astrophysical and statistical analyses of CC support the idea that this was the period of the eclipsing binary Algol three millennia ago. However, next to nothing is known about who recorded Algol's period into CC and especially how. Here, we show that the ancient Egyptian scribes had the possible means and the motives for such astronomical observations. Their principles of describing celestial phenomena as activity of gods reveal why Algol received the title of Horus

Keywords: Algol, Horus, ancient Egyptian Astronomy, variable stars, the Cairo Calendar, hemerologies

1 Introduction

The ancient Egyptian texts known as the Calendars of Lucky and Unlucky Days, or hemerologies, are literary works that assign prognoses to each day of the Egyptian year (Wells 2001a), (Leitz 1994) (Bacs 1990) (Troy 1989) and (Helck et al. 1975–1992). These prognoses denote whether the day, or a part of the day, is considered “good”[▲] or “bad”[▲]. ¹ Nine such texts have been found (Troy 1989), (Leitz 1994) and (Porceddu et al. 2008). Here, we study the best preserved one of these nine texts, CC, dated to 1271–1163 B.C. (Bakir 1966), (Van Walsem 1982) and (Helck et al. 1975–1992), and published by Abd el-Mohsen Bakir. As in all our three previous studies (Porceddu et al. 2008; Jetsu et al. 2013; Jetsu and Porceddu 2015), we use *only the best*

preserved continuous calendar which is found on pages recto III-XXX and verso I-IX of papyrus Cairo 86637. The other texts and fragments contained in the same papyrus are ignored from this analysis because the connection of these fragments to the main calendar is not apparent and we do not know what year they describe, so combining any data points from these sources to the dataset created from the long Cairo Calendar would introduce a random noise component to the analysis. All CC text passages we quote in this article have been translated by us from the hieroglyphic transcription of Leitz (1994), assisted by the translations of Bakir (1966, in English) and Leitz (1994, in German).

The synodic period of the Moon was discovered in CC with a statistical method called the Rayleigh test, as well as a few other periods (Porceddu et al. 2008). In a footnote of that study, it was noted that one seemingly less significant period, 2.850 days, was rather close to the current 2.867 days period of Algol (β Persei). This star is a prototype of a class of stars called eclipsing binaries. The two stars, Algol A and Algol B, orbit around a common centre of mass with a period of 2.867 days. Algol A is brighter than Algol B. However, Algol B has a larger radius than Algol A. Our line of sight nearly coincides with the orbital plane of this double star system. Therefore, these stars eclipse each other during every orbital round. In a primary eclipse, the dimmer Algol B partly eclipses the brighter Algol A. This primary eclipse can be observed with naked eye. In a secondary eclipse, the brighter Algol A partly eclipses the dimmer Algol B, but the decrease in total brightness of this

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¹ We use the symbol “▲” to denote the words and phrases translated into Ancient Egyptian language in the list of Appendix A.

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binary system is so small that this secondary eclipse event can not be observed with naked eye. Hence, the brightness of Algol appears to remain constant for a naked eye observer, except during the primary eclipses. These primary eclipses last about ten hours. For most of the time, Algol is brighter than its six close-by bright comparison stars (Jetsu *et al.* 2013, their Figure 5a). During a primary eclipse, Algol first becomes dimmer for five hours and then regains its brightness in another five hours. For a few hours, Algol appears visibly dimmer than all its six comparison stars. A naked eye observer can easily notice this as a clear change in Algol's constellation pattern.

The normalized Rayleigh test of the CC data confirmed the high significance of the 2.850 days period (Jetsu *et al.* 2013). The period increase from 2.850 to 2.867 days during the past three millennia gave a mass transfer rate estimate from Algol B to Algol A. This estimate of Jetsu *et al.* (2013) agreed with the one predicted by the best evolutionary model of Algol (Sarna 1993). A sequence of eight astronomical criteria was also presented which proved that the ancient Egyptians could have discovered Algol's periodic variability with naked eyes (Jetsu *et al.* 2013), *i.e.* it is the star where it is easiest to discover regular short-term variability without the aid of a telescope.

In the Hellenistic tradition, Algol was called “the head of Gorgon”. Similar tradition was continued in the Arabic name “Demon's Head”. The name Algol is derived from the Arabic word, head of the Ghoul (ra's al-ghūl) (Davis 1957). These names seem to indicate that some exotic or foreboding feature or mutability was known in the folklore of the ancient peoples. All the way to medieval astrology, the ill omens associated with the “evil eye” of Algol were known, so it is actually surprising that it is so difficult to find any direct reference to Algol's variability in old astronomical texts (Davis 1957). The list of ill-omened names is so impressive (Allen 1899) that it is unlikely that the variability would have gone undetected through millennia of practical star observing by the ancient Egyptians.

Of the modern astronomers, Fabricius discovered the first variable star, Mira, in 1596. The second variable star, Algol, was discovered by Montanari in 1669. Goodricke (1783) determined the 2.867 days period of Algol in 1783. A close friend and tutor of John Goodricke, Edward Pigott, also discovered several new variable stars (Hoskin 1979). In his last paper, Pigott (1805) argued that the brightness of Algol must have been constant in Antiquity, because the variability that he observed was so easy to notice with naked eyes. Kopal (1946) suggested that those ancient discoveries “may have been buried in the ashes of the Library of Alexandria”. More recently, Wilk (2000) has presented the theory that classical mythology contains knowledge of

the variability of various stars, including Algol. This star also seems to belong to the constellation called “Elk” by the Siberian shamans of the Khanty tribe, who have noticed that this animal sometimes loses one pair of legs (Pentikäinen 1997).

A statistical analysis of 28 selected words (hereafter SWs) of the mythological narratives of CC was performed to find traces of the Egyptians' symbolism for Algol (Jetsu and Porceddu 2015). We notate the SWs of that particular study for example “Horus” or “Seth” to distinguish them from other Egyptian deities such as Isis and Nephthys. Out of all 28 SWs, the word “Horus” had the strongest connection to the 2.850 days periodicity (Jetsu and Porceddu 2015). “Horus”, etymologically “the distant one”, was one of the earliest attested Egyptian deities. Predominantly a sky god or stellar god, the living king was identified as an earthly “Horus” (Roeder 1994) and (Meltzer 2001). Horus is described as a star in the oldest ancient Egyptian texts (Krauss 2016). Another deity, “Seth”, the adversary of “Horus”, was shown to be connected to the period of the Moon (Jetsu and Porceddu 2015).

Statistical analyses have confirmed the ancient Egyptian discovery of Algol's period (Porceddu *et al.* 2008; Jetsu *et al.* 2013; Jetsu and Porceddu 2015). Here, our aim is to connect this astonishing ancient discovery to its contemporary cultural and historical background by presenting ten general arguments about CC (Sects 4.1-4.10). These arguments strongly support the idea that the ancient Egyptian scribes had the possible means and the motives to record Algol's period into CC. The connection of CC mythological texts to the perceived behaviour of the Moon and Algol is verified in Sects 4.7 and 4.8.

2 Materials and Methods

2.1 Materials

We use statistical methods to discover the principles of describing celestial phenomena in CC, thus no other Egyptian texts are used as material in the core analysis. We begin with a general description of CC.

This document is one of the texts known as Calendars of Lucky and Unlucky Days. In these Calendars the days of the year are assigned good and bad prognoses. Nine full and partial Calendars of Lucky and Unlucky Days have been discovered (Leitz 1994), (Troy 1989) and (Helck *et al.* 1975–1992). Eight of them date to the New Kingdom, ca. 1550-1069 B.C., while one of them is from the Middle Kingdom, ca. 2030-1640 B.C. Papyrus Cairo 86637, the source

of CC, was originally dated to the ninth regnal year of Ramses II (Brunner-Traut 1970), around 1271-1270 B.C. according to the generally accepted chronology (Shaw 2000) which has been disputed (Huber 2011). However, the date is nowhere to be explicitly found (Leitz 1994). Van Walsem (1982) revised the date of the papyrus to the early 20th dynasty, around 1185-1176 B.C. We have also checked the paleographical correspondences of plentifully recurring signs, such as F35, G17, N5, O1 and R8 (Wimmer 1995), and these seem to support the conclusion of dating the manuscript to the latter half of the 19th dynasty or the beginning of the 20th, *i.e.* 1244-1163 B.C. A compromise date 1224 B.C. was used in the astrophysical and astronomical computations (Jetsu *et al.* 2013), as well as in the SW analysis (Jetsu and Porceddu 2015). The results of both of those studies did not depend on the exact dating of CC.

CC is a calendar for the entire year. We use the daily prognoses of CC published in Table 1 of Jetsu *et al.* (2013), where the German notations by Leitz (1994) were used (G=Gut= “good”, S=Schlecht=“bad”). CC is based on the Civil Calendar of 12 months of 30 days each plus five additional epagomenal days for which no prognoses are given. The months were arranged into three seasons of four months each. These seasons were Akhet (flood season)[▲], Peret (winter season)[▲] and Shemu (harvest season)[▲]. The conventionally given format for a calendar date is for example I Akhet 27 for the 27th day of the first month of the Akhet season.

The CC texts systematically give a date, inscribed in red colour, and then three prognoses for that date (FAQ 1)². For example, the GGG prognosis combination for the date I Akhet 27 means that all the three parts of the day are lucky. This fully positive prognosis is the most common for any day. Kemp and Rose (1991) noted that the ratio of good and bad prognoses in CC is close to the value of the so-called Golden Section, in accordance with modern psychological experiments regarding positive and negative judgements.

Generally speaking, on SSS days people were under a special threat to suffer from hunger, thirst and various illnesses. The prognoses of such days were attributed to mostly negative mythological events and children born on such a date might have been foretold to die of illness. On the other hand, those born on GGG days would live a long life. Such days were in general supposed to consist of joy, success, freedom, health and various feasts. While on SSS days some restrictions were suggested on journeying and

consumption of foods, on GGG days it was recommended to give offerings and feasts to the gods (Troy 1989).

In the longer and better preserved texts, especially in CC, there are descriptions of mythological events relating to the date and also some instructions on suggested behaviour during the day (FAQ 1). For example, regarding the day I Akhet 27 the description in CC, page recto VIII, reads that the god “Horus” and his enemy “Seth” are resting from their perpetual struggle. It is recommended not to kill any “snakes”[▲] during the day. The practical influence of the Calendars of Lucky and Unlucky Days on the life of ancient Egyptians is not exactly known. The various instructions and restrictions such as “make offering to the gods of your city” (Leitz 1994) or “do not go out of your house to any road on this day” (Leitz 1994) seem to be presented in the context of the everyday life of a worker. It was suggested that the Calendars of Lucky and Unlucky Days would have determined the rest days for the workers (Helck *et al.* 1975–1992), but no correlation of the Lucky and Unlucky Days was found with days of kings’ ascensions to throne, official building works, battles, journeys, court trials or working days, except when the day was also a regular feast date (Drenkhahn 1972). In CC, the prognosis of the first day of each month is always GGG and the day is called “feast”[▲]. On the other hand, the prognosis of the 20th day of each month is always SSS.

In most cases, the prognosis is homogeneous for the whole day (*i.e.* GGG or SSS). There are only 29 heterogeneous prognoses in CC. These days provide a glimpse into the logic behind the day division. Generally speaking, arrangement into morning, mid-day and evening is obvious, but these can be defined in multiple ways. For example, the prognosis for the date I Akhet 8 in CC is GGS. The text advises one not to go out during the “night”[▲]. The prognosis for I Akhet 25 is also GGS but the text advises one not to go out during the “evening”[▲]. Thus it remains unclear if the third part of the day comprises night hours as well. Jetsu *et al.* (2013) showed that the period analysis results for CC did not depend on how the three prognoses were distributed within each day.

The practice of assigning good and bad omens to days of the year seems rather close to astrology and reading predictions from the stars, and indeed the Calendar of Lucky and Unlucky Days was mixed with Babylonian based astrology in the Greek and Roman times (Leitz and Thissen 1995). But it is to be noted that celestial matters did not fully determine the prognoses in the Calendar of Lucky and Unlucky days, but played a part in it alongside natural cycles such as the floods of the Nile, or the seasonal dangers presented by winds, wild animals and illnesses. There is also plenty of evidence for various kinds of rit-

² Some frequently asked questions (FAQ) about our research have been collected into Appendix B, where we give short answers those questions, as well as indicate the sections of this manuscript where the more detailed answers can be found.

ual recurrence, such as that III Akhet 26 is described the strengthening of “the djed-pillar”[▲] (Helck et al. 1975–1992, a ritual object whose raising is connected to the myth of the resurrection of the god Osiris who was killed by Seth) and II Peret 6 is described the erection of “the djed-pillar”, with a separation of exactly 70 days, the approximate interval between Sirius’ heliacal setting and Sirius’ heliacal rising. It was considered the ideal duration of funerary ceremonies because the star was believed to spend this time in the underworld, undergoing rituals of purification. CC also makes explicit references to the heliacal rising, culmination and heliacal setting of certain hour-stars (Hardy 2003). All prognoses based on this type of aperiodic events induce statistical noise into CC. When applying period analysis to the CC data, this noise interferes with the detection of any periodic signal.

When searching for regular periodic astronomical phenomena in CC, one should realize that only a few events relating to celestial objects, however important they were considered to be, could have determined an extensive and significant set of periodic prognoses. For example, the heliacal rising of a star is a yearly event, and may affect the prognosis of one day. Thus, it can not be discovered from the calendars by period analysis. The synodic periods of planets, because of their length, are also out of the question (Jetsu et al. 2013). Except for the Moon, the only other detectable astronomical periods in CC are those of the regular brightness changes of a variable star (Jetsu et al. 2013).

2.2 Methods

We relate CC texts to astronomical events by the phase angles calculated from the days that the texts refer to (Eqs. 1–4). We select four samples from CC (Tables 1–4) which give us two lists of CC text passages (Lists 1 and 2).

Recently, a statistical study was made of the occurrence of 28 different SWs in the CC prognosis texts (Jetsu and Porceddu 2015). The occurrences of individual SWs were studied separately. The lucky prognosis texts mentioning “Horus” were studied in greater detail, and a few unlucky texts mentioning “Sakhmet” or “Seth”. Those texts were taken as such from the CC translation of Bakir (1966).

We downloaded these SW data (Jetsu and Porceddu 2015) from the Dryad database³, where the respective ASCII file-name is *data2.txt*. This gave us the dates when any particular SW is mentioned in CC. Here, we con-

Table 1. “GGG” prognosis texts mentioning Horus, Wedjat or Sakhmet. The columns are SW (Selected word), ancient Egyptian month (“Month”), day (D), numerical month value (M), time point ($g(D, M)$) and the phase angles (θ_{Algol} and θ_{Moon}). All values are in the order of increasing θ_{Algol} , because this allows an easy comparison with the results shown in List 1 and Figure 1.

SW	Month	D	M	$g(D, M)$	θ_{Algol}	θ_{Moon}
Horus	II Akhet	14	2	43.33	6	124
Wedjat	I Peret	1	5	120.33	13	341
Sakhmet	I Peret	1	5	120.33	13	341
Horus	IV Shemu	19	12	348.33	13	234
Horus	I Akhet	27	1	26.33	19	278
Horus	III Akhet	24	3	83.33	19	251
Horus	III Peret	1	7	180.33	32	351
Horus	III Akhet	27	3	86.33	38	287
Horus	III Shemu	15	11	314.33	38	180
Horus	I Shemu	1	9	240.33	51	0
Wedjat	II Akhet	3	2	32.33	57	351
Horus	I Shemu	7	9	246.33	88	73
Horus	III Akhet	28	3	87.33	164	300
Horus	II Shemu	1	10	270.33	240	5
Sakhmet	IV Akhet	16	4	105.33	278	158
Horus	III Peret	23	7	202.33	291	258
Horus	III Akhet	29	3	88.33	291	312
Sakhmet	I Peret	9	5	128.33	303	78
Wedjat	II Shemu	30	10	299.33	303	358
Sakhmet	I Peret	29	5	148.33	309	321
Horus	I Akhet	18	1	17.33	322	168
Wedjat	I Shemu	6	9	245.33	322	61

Table 2. “SSS” prognosis texts mentioning Horus, Wedjat or Sakhmet. Notations are as in Table 1.

SW	Month	D	M	$s(D, M)$	θ_{Algol}	θ_{Moon}
Horus	IV Peret	5	8	214.33	6	44
Horus	I Akhet	26	1	25.33	253	265
Horus	III Shemu	11	11	310.33	253	132
Wedjat	II Peret	10	6	159.33	259	95
Sakhmet	IV Peret	27	8	236.33	265	312
Sakhmet	II Peret	13	6	162.33	278	132
Sakhmet	II Shemu	7	10	276.33	278	78
Horus	I Shemu	20	9	259.33	291	231

centrate on the following five particular SWs: “Horus”, “Wedjat”, “Sakhmet”, “Seth” and “Osiris”. These five deities are the most relevant ones regarding the two prominent myths “The Destruction of Mankind” and “The Contendings of Horus and Seth” that will be described in Sect. 4.7.

“Horus”, etymologically the distant one, was a sky god or stellar god associated with kingship and order. Krauss (2016) suggests that Horus was originally a stellar god who later became subordinated to solar mythology. Already the earliest texts regarding Horus describe him as the “Foremost star of the sky”. In the Pyramid Texts, a younger Horus is called Horus-son-of-Isis and is distin-

³ <http://dx.doi.org/10.5061/dryad.tj4qq>

Table 3. “GGG” prognosis texts mentioning Horus, Seth or Osiris. Notations are as in Table 1, except that all values are in the order of increasing θ_{Moon} .

SW	Month	D	M	$g(D, M)$	θ_{Algol}	θ_{Moon}
Horus	I Shemu	1	9	240.33	51	0
Horus	II Shemu	1	10	270.33	240	5
Osiris	II Shemu	1	10	270.33	240	5
Osiris	III Peret	6	7	185.33	303	51
Seth	IV Akhet	9	4	98.33	114	73
Horus	I Shemu	7	9	246.33	88	73
Osiris	IV Akhet	11	4	100.33	6	98
Horus	II Akhet	14	2	43.33	6	124
Osiris	II Akhet	16	2	45.33	259	149
Seth	IV Shemu	13	12	342.33	335	161
Osiris	IV Shemu	13	12	342.33	335	161
Horus	I Akhet	18	1	17.33	322	168
Horus	III Shemu	15	11	314.33	38	180
Osiris	II Peret	17	6	166.33	63	180
Horus	IV Shemu	19	12	348.33	13	234
Horus	III Akhet	24	3	83.33	19	251
Horus	III Peret	23	7	202.33	291	258
Horus	I Akhet	27	1	26.33	19	278
Seth	I Akhet	27	1	26.33	19	278
Horus	III Akhet	27	3	86.33	38	287
Seth	III Akhet	27	3	86.33	38	287
Horus	III Akhet	28	3	87.33	164	300
Osiris	III Akhet	28	3	87.33	164	300
Horus	III Akhet	29	3	88.33	291	312
Seth	III Akhet	29	3	88.33	291	312
Osiris	III Peret	28	7	207.33	202	319
Horus	III Peret	1	7	180.33	32	351

guished from the elder Horus (Haroeris). According to Krauss these would be Venus as the morning star and the evening star. On one hand the connection of the planet Venus, usually considered feminine, with the king would be unique to Egypt. Yet Venus was certainly associated with Benu, the divinity who in the creation myth laid the first stone *benben*, which became Earth, upon the primal sea. Horus' rival god Seth was the embodiment of disorder, identified in some sources with the planet Mercury, the other inner planet besides Venus. In the most commonly known mythological narrative Osiris, the father of Horus, was killed by Seth. Horus avenged his father and the resurrected Osiris was to be considered the patron of the dead, especially the dead king (Meltzer 2001). Sakhmet was a lion goddess associated with the scorching, destructive power of the Sun, also called Wadjet or the Eye of Horus (Leitz and Budde 2003) and (Jong 2001).

While Jetsu and Porceddu (2015) studied *some* texts mentioning “Horus”, “Sakhmet” or “Seth”, and used the text from the CC translation of Bakir (1966), we study *all* prognosis texts mentioning *any* of the above mentioned

Table 4. “SSS” prognosis texts mentioning Horus, Seth or Osiris. Notations are as in Table 3.

SW	Month	D	M	$s(D, M)$	θ_{Algol}	θ_{Moon}
Horus	IV Peret	5	8	214.33	6	44
Seth	II Akhet	12	2	41.33	114	100
Seth	III Akhet	13	3	72.33	69	117
Osiris	III Akhet	13	3	72.33	69	117
Osiris	III Akhet	14	3	73.33	196	129
Horus	III Shemu	11	11	310.33	253	132
Seth	IV Shemu	11	12	340.33	82	137
Osiris	I Peret	14	5	133.33	215	139
Seth	III Akhet	18	3	77.33	341	178
Seth	III Peret	17	7	196.33	253	185
Seth	IV Peret	17	8	226.33	82	190
Osiris	IV Akhet	19	4	108.33	297	195
Seth	II Akhet	20	2	49.33	44	197
Horus	I Shemu	20	9	259.33	291	231
Horus	I Akhet	26	1	25.33	253	266
Seth	I Akhet	26	1	25.33	253	266
Seth	IV Peret	24	8	233.33	246	275

five deities, and we use our own translations of these CC texts.

We calculate the “Egyptian days” for these SWs from

$$N_E = 30(M - 1) + D, \quad (1)$$

where M is the month and D is the day of the date in CC (Jetsu et al. 2013, Table 1). The SW dates are transformed (Jetsu and Porceddu 2015) into time points with the relation

$$t = t(D, M) = N_E - 1 + 0.33. \quad (2)$$

We use the notations $g = g(D, M) = t(D, M)$ and $s = s(D, M) = t(D, M)$ for the time points of GGG and SSS prognosis days, because these two prognosis samples were analysed and studied separately (Jetsu et al. 2013; Jetsu and Porceddu 2015).

For any period value P , the phases of t are

$$\phi = \text{FRAC}[(t - t_0)/P], \quad (3)$$

where FRAC removes the integer part of $(t - t_0)/P$ and t_0 is the zero epoch. In other words, FRAC removes the number of full P rounds completed after the zero epoch t_0 . The phase angles are

$$\theta = 360^\circ \phi. \quad (4)$$

Jetsu et al. (2013) discovered two significant periods, $P_{\text{Algol}} = 2.850$ and $P_{\text{Moon}} = 29.6$ days, in the lucky prognoses of CC. In their next study, they determined these two ephemerides (Jetsu and Porceddu 2015) for the phases of Eq. 3

$$t_0 = 0.53, P = P_{\text{Algol}} = 2.850 \quad (5)$$

$$t_0 = 3.50, P = P_{\text{Moon}} = 29.6 \quad (6)$$

The phase angles Θ (Eq. 4) computed with the ephemerides of Eqs. 5 and 6 are hereafter denoted with Θ_{Algol} and Θ_{Moon} , respectively. We also use their eight abbreviations (Jetsu and Porceddu 2015)

Aa $\equiv \Theta_{\text{Algol}} = 0^\circ$ = Mid-epoch of Algol's secondary eclipse

Ab $\equiv \Theta_{\text{Algol}} = 90^\circ$ = Between mid-epochs of secondary and primary eclipse

Ac $\equiv \Theta_{\text{Algol}} = 180^\circ$ = Mid-epoch of Algol's primary eclipse

Ad $\equiv \Theta_{\text{Algol}} = 270^\circ$ = Between mid-epochs of primary and secondary eclipse

Ma $\equiv \Theta_{\text{Moon}} = 0^\circ$ = Full Moon

Mb $\equiv \Theta_{\text{Moon}} = 90^\circ$ = Between Full and New Moon

Mc $\equiv \Theta_{\text{Moon}} = 180^\circ$ = New Moon

Md $\equiv \Theta_{\text{Moon}} = 270^\circ$ = Between New and Full Moon

All D , M , $g(D, M)$, $s(D, M)$, Θ_{Moon} and Θ_{Algol} values of “Horus”, “Wedjat”, “Sakhmet”, “Seth” and “Osiris” are given in Tables 1-4.

We study all CC passages mentioning “Horus”, “Wedjat”, “Sakhmet”, “Seth” and “Osiris”. These passages give the date first, inscribed in red colour. Then follow the daily prognoses, and the descriptive prognosis text. The time point for every date is unambiguous, because the structure of CC is regular, 12×30 days (Eqs. 1 and 2). Hence, the time points for the prognoses, the SWs and the prognosis texts describing the actions of deities are also unambiguous.⁴ The exact dating of the CC, as a historical document, is irrelevant in the current analysis, like it also was in the previous statistical studies (Jetsu et al. 2013; Jetsu and Porceddu 2015). Adding any arbitrary constant to the time points of Eq. 2 shifts all phase angles Θ with the same amount, e.g. the Θ_{Algol} values of all passages of List 1. This is the reason why our results based on Lists 1 and 2 do not depend on such shifts (FAQ 2).

The number of passages mentioning some SWs is very small (e.g. $n = 3$ for “Sakhmet” in Table 2). It is therefore necessary to explain how can we draw reliable statistical conclusions from the analysis of such data (FAQ 3). Firstly, the periods P_{Algol} and P_{Moon} were detected from large samples of over five hundred time points and these periodicities were extremely significant (Jetsu et al. 2013). For example, the period P_{Algol} reached critical levels $Q^* < 0.0001$ (Jetsu et al. 2013, Table 7), i.e. the probability for this period

being real was $1 - Q^* > 0.9999$. Secondly, the ephemerides of Eqs. 5 and 6 are also very reliable, because they were determined from the same large data samples (Jetsu and Porceddu 2015). Thirdly, although the Rayleigh test significance estimates computed by Jetsu and Porceddu (2015, their Eq. 8: Q_z) for some smaller samples were not reliable, the binomial distribution significance estimates for the very same samples were certainly reliable (their Eq. 13: Q_B). Fourthly, the *order* of the passages in Lists 1 and 2 is the same (i.e. unambiguous) for any arbitrary epoch t_0 in Eqs. 5 and 6. For these four reasons, the phase angles computed from the ephemerides of Eqs. 5 and 6 can be used just like the time given by an accurate modern clock. For example, such a clock shows that most people go to sleep before midnight. It is irrelevant if only a few (small n), or many (large n), people go to sleep. Rearranging the texts of CC into the increasing order of Θ_{Algol} may show what the authors of CC wrote about “Horus” at different phases of the cycle (FAQ 4).

It is possible to dispute our translations of the texts of Lists 1 and 2 (FAQ 5), but these translations are relevant only for the two Arguments VII and VIII, i.e. the validity of the eight other arguments in Sects. 4.1-4.10 does not depend on these translations. In these translations, we have used the English translation by Bakir (1966) and the German translation by Leitz (1994), and his transcript of the original papyrus, as well as photos of the original papyrus. For example, all 460 SW identifications by Jetsu and Porceddu (2015) and Leitz (1994) were identical, and here we use the same SW list. Some words or sentences could be translated differently, but that would not change the general description of the course of events in the translated passages of Lists 1 and 2. Also the prognoses, which were taken as such from Leitz (1994), are independent of any translation nuances.

A non-parametric method, the Rayleigh test, has been applied to the series of n time points t_1, t_2, \dots, t_n of CC (Jetsu et al. 2013; Jetsu and Porceddu 2015). Here we study the SWs and the CC texts of these time points. These time points are circular data and a “non-parametric” method means that there is no model. It has been suggested that we should apply a χ^2 -test to our data (FAQ 6). This “parametric” test could be applied if the format of our data were $y(t_1), y(t_2), \dots, y(t_n)$, i.e. a time series, like magnitudes of a star as function of time. The value of this test statistic is $\chi^2 = \sum_i^n [y(t_i) - g(t_i)]^2 / \sigma_i^2$, where $g(t_i)$ is the value of the model at t_i and σ_i is the error of $y(t_i)$. However, we can not apply this χ^2 -test, because we have no time series, no model and no errors.

⁴ The calendar dates are fixed and known even if the texts or the deities mentioned in these texts were not studied at all. The deities mentioned in these texts do not determine the dates (FAQ 1).

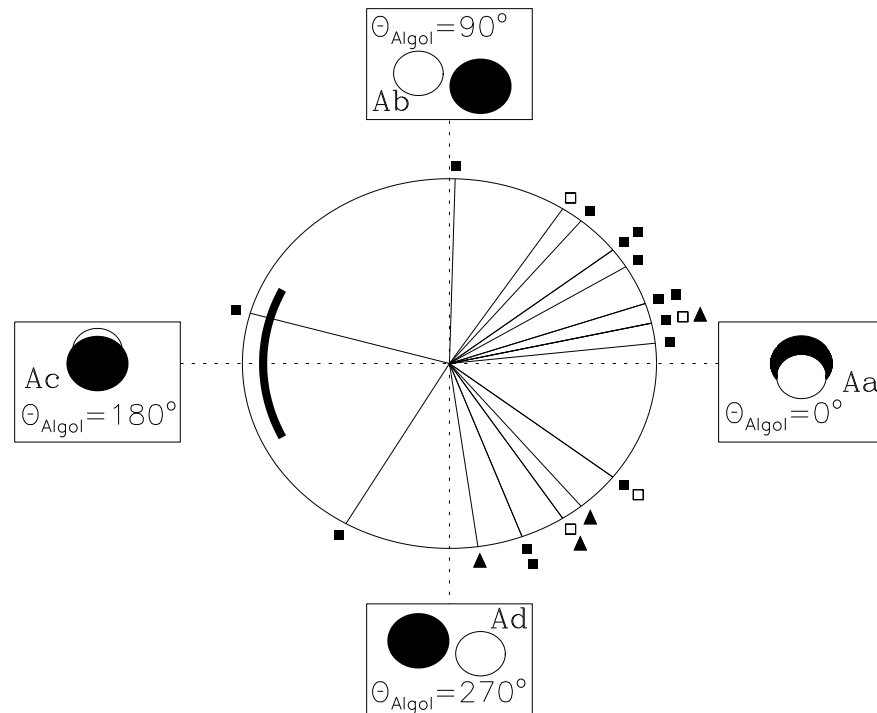


Figure 1. Θ_{Algol} phase angles of lucky time points of Table 1. Time runs in the counter-clockwise direction on this circle. Epochs Aa, Ab, Ac and Ad are separated by 90 degrees and they are denoted with dotted straight lines. The relative locations of Algol A (white disk) and Algol B (black disk) at these four epochs are shown in the small boxes. Primary and secondary eclipses of Algol occur at Ac and Aa, respectively. The thick curved line centered at Ac outlines the phase angles of the 10 hour primary eclipse of Algol at $153.7^\circ < \Theta_{\text{Algol}} < 206.3^\circ$. The phase angle values Θ_{Algol} of “Horus” (closed squares), “Wedjat” (open squares) and “Sakhmet” (closed triangles) are denoted with continuous straight lines.

3 Results

3.1 Algol: Horus, Wedjat and Sakhmet passages of List 1

The lucky and unlucky days of CC texts mentioning “Horus”, “Wedjat” or “Sakhmet” are given in Tables 1 and 2, respectively. We rearrange our translations of CC passages of “Horus”, “Wedjat” and “Sakhmet” into the order of increasing Θ_{Algol} in List 1 of Appendix C. These passages are discussed in Sect. 4.8. We highlight the unlucky CC prognosis text passages with red colour, to visually distinguish these unlucky texts from the lucky ones, since red colour is also used in CC for writing the prognosis “bad” and the name of the feared serpent creature Apep. Other texts in papyrus Cairo 86637 display an even more varied use of red colour for the sake of emphasis and captioning (Bakir 1966).

The Θ_{Algol} values of the $g(D, M)$ and $s(D, M)$ time points of List 1 are shown separately in Figures 1 and 2. The

relative positions of Algol A (white disk) and Algol B (black disk) at points Aa, Ab, Ac and Ad are shown in four small boxes of Figures 1 and 2. For a naked eye observer, Algol’s brightness appears constant, except for the 10 hour dimming during Θ_{Algol} values marked with a thick curved line centered at Ac. These eclipse phase angles are in the interval $153.7^\circ \leq \Theta_{\text{Algol}} \leq 206.3^\circ$. Time runs in the counter-clockwise direction. One complete orbital round P_{Algol} is $Aa \rightarrow Ab \rightarrow Ac \rightarrow Ad \rightarrow Aa$.

The lucky time points $g(D, M)$ of SWs having $-90^\circ < \Theta_{\text{Algol}} < 90^\circ$ amplify the $P_{\text{Algol}} = 2.85$ signal (Jetsu and Porceddu 2015). The closer a Θ_{Algol} value of some $g(D, M)$ is to the point Aa at $\Theta_{\text{Algol}} = 0^\circ$ in Figure 1, the greater is the amplifying impact of this $g(D, M)$ value on the P_{Algol} signal. A previous study by Jetsu and Porceddu (2015) showed that of all their 28 SWs, “Horus” had the strongest impact on the P_{Algol} signal. The other remaining SWs having an impact on the P_{Algol} signal were “Re”, “Wedjat”, “Followers”, “Sakhmet” and “Ennead”.

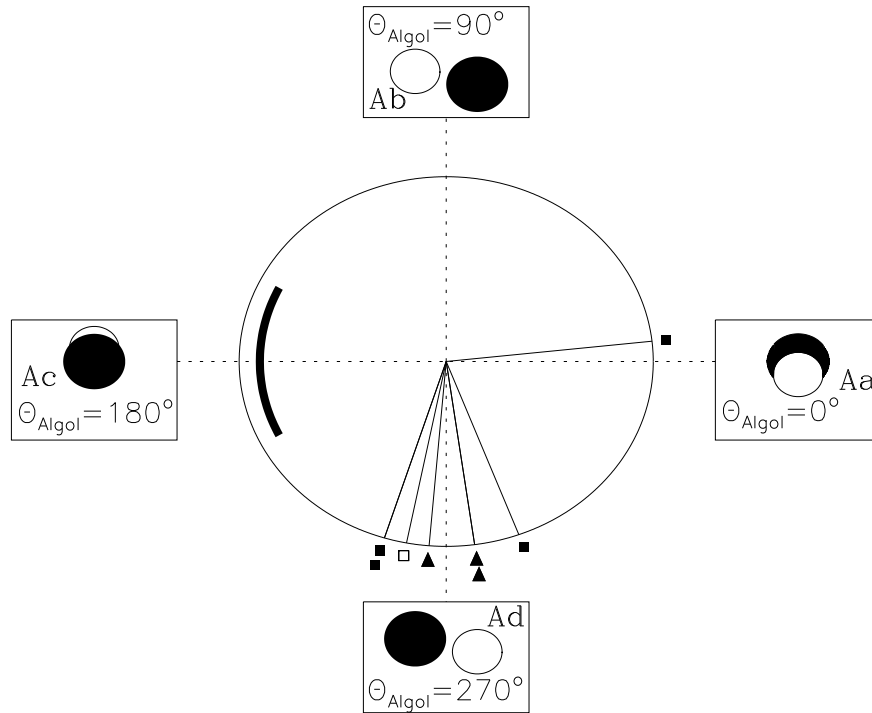


Figure 2. Θ_{Algol} of unlucky time points of Table 2. Notations as in Figure 1.

3.2 Moon: Horus, Seth and Osiris passages of List 2

The lucky and unlucky days of CC texts mentioning “Horus”, “Seth” or “Osiris” are given in Tables 3 and 4. Our translations of CC passages mentioning “Horus”, “Seth” and “Osiris” are rearranged into the order of increasing Θ_{Moon} in List 2 of Appendix D. We discuss these passages in Sect. 4.8.

The Θ_{Moon} values of the $g(D, M)$ and $s(D, M)$ time points of List 2 are shown in Figs 3 and 4. The appearance of the lunar disk at points Ma, Mb, Mc and Md is illustrated in four small boxes of Figures 3 and 4. Again, time runs in the counter-clockwise direction, where one complete synodic lunar month P_{Moon} is $\text{Ma} \rightarrow \text{Mb} \rightarrow \text{Mc} \rightarrow \text{Md} \rightarrow \text{Ma}$.

The time points $g(D, M)$ of SWs with phase angles Θ_{Moon} close to $\Theta_{\text{Moon}} = 0^\circ$ amplify the $P_{\text{Moon}} = 29.46$ signal. Jetsu and Porceddu (2015) showed that of all their 28 SWs, “Earth” and “Heaven” had the strongest impact on the P_{Moon} signal, i.e. their lucky prognoses were close to the Ma point. This is natural because lunar feast dates were often described as feasts in “Earth” and in “Heaven” (FAQ 4). The other SWs connected to P_{Moon} were “Busiris”, “Rebel”, “Thoth” and “Onnophris” (Jetsu and Porceddu 2015). The unlucky time points $s(D, M)$ of two SWs, “Seth”

and “Osiris”, pointed to the opposite direction, $\Theta_{\text{Moon}} = 180^\circ$. The CC texts of “Seth” strongly indicated that $\Theta_{\text{Moon}} = 180^\circ$ coincided with the New Moon. Hence, it was concluded that $\Theta_{\text{Moon}} = 0^\circ \equiv \text{Ma}$ represented the Full Moon (Jetsu and Porceddu 2015). These connections are hardly surprising either because “Osiris”, also called “Onnophris”, was identified with the Moon during the New Kingdom (Kaper 2001). “Thoth” was another known lunar god (Leitz and Budde 2003). “Busiris” was the place of origin for “Osiris”. “Rebel” is often synonymous for “Seth” (Leitz 1994).

Note that the texts mentioning “Horus” are included in both Lists 1 and 2, because the name “Horus” appears in both mythical narratives of Sects. 4.7.1 and 4.7.2. However, the order of these “Horus” texts is different when rearranged in the order of increasing Θ_{Algol} or Θ_{Moon} .

4 Discussion

We present one argument about CC in the end of each Sect. 4.1-4.10.

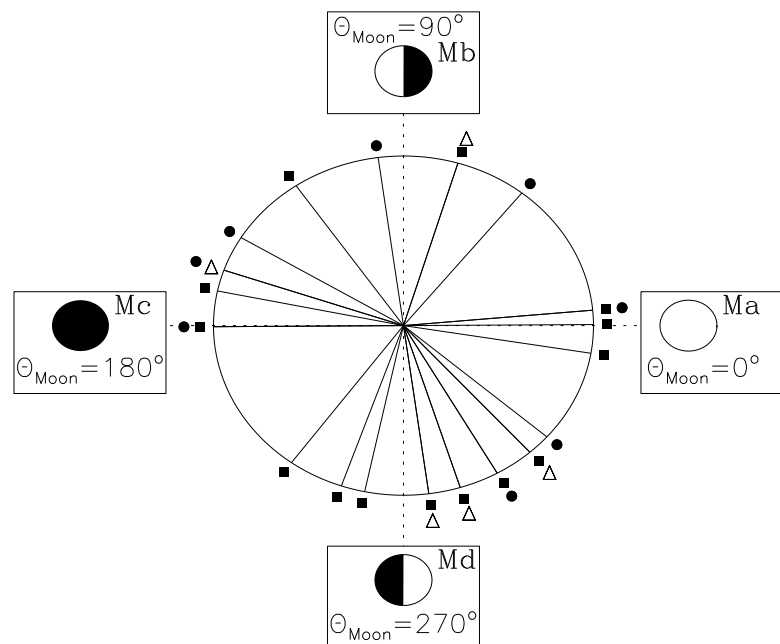


Figure 3. θ_{Moon} of the lucky time points of Table 3. Time runs in the counter-clockwise direction on this circle. Epochs Ma, Mb, Mc and Md are separated by 90 degrees and they are denoted with dotted straight lines. The phases of the Moon are shown in the small boxes. The Full and the New Moon occur at Ma and Mc, respectively. The phase angle values θ_{Moon} of “Horus” (closed squares) “Seth” (open triangles) and “Osiris” (closed circles) are denoted with continuous straight lines.

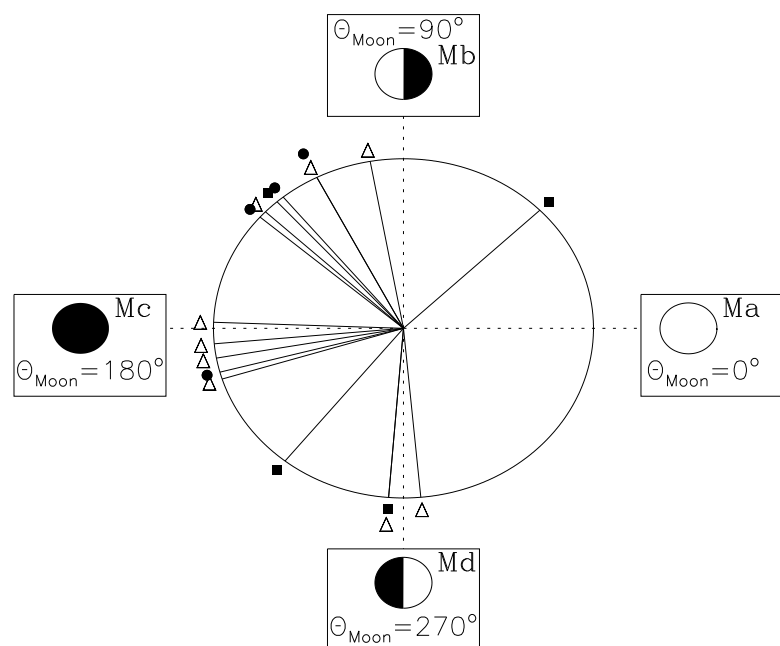


Figure 4. θ_{Moon} of the unlucky time points of Table 4. Notations as in Figure 3.

4.1 Measuring night-time with hour-stars

At the night-time in ancient Egypt, time was traditionally measured from the positions of hour-stars.

The ancient Egyptian day was split into daytime and night-time, both with 12 hours. Time was counted using shadow clocks by day, and star clocks or water clocks by night. The Egyptian “hour-watcher”[▲] was a specialized scribe whose job was to observe various hour-stars, i.e. clock stars whose positions began and ended the night hours (Figure 5). More specifically, a text previously known as “The Cosmology of Nut” whose title was deciphered by Lieven (2007) to be “The Fundamentals of the Course of the Stars” informs us that stars were traditionally observed when in positions of the “culmination”[▲] upon the first hour of the night (transit of the meridian between the eastern half of the sky and the western half of the sky), “heliacal setting”[▲] and “heliacal rising”[▲] (Clagett 1995). Tabulated positions of hour-stars marked the closing of each night hour. One approximation for the length of an Egyptian night hour was 40 minutes (Leitz and Thissen 1995).

The Ramesside Star Clocks from the tombs of Ramses VI, Ramses VII and Ramses IX show an even more complex arrangement of hour-stars (Clagett 1995). Each table consists of thirteen rows of stars. The first row stands for the opening of the first night hour and the other twelve rows stand for the closing of each of the twelve night hours. In the rows, a star is positioned in respect to a sitting human figure. Possible positions are “upon the right shoulder”[▲], “upon the right ear”[▲], “upon the right eye”[▲], “opposite the heart”[▲], “upon the left eye”[▲], “upon the left ear”[▲], and “upon the left shoulder”[▲] (Figure 5). The system was originally interpreted as two hour-watchers opposite to each other on the roof of the temple precisely aligned to the line of the meridian. These timing observations would have been necessarily made towards south, because of the positions of the hour-stars. The hour-watcher facing south might have utilized a plumb and a sighting device to determine when the given star is in exactly the right position and announce the closing of the hour. If the hour-watchers were positioned 2-3 meters away from each other, the slow rotation of the night sky would have provided a 10-15 minute difference between the marked positions (Leitz and Thissen 1995). According to Lull and Belmonte (2009) it is more likely that the figure that had been interpreted as an hour-priest would rather be a divinity associated with time-keeping, leading to revised ideas regarding the direction of the observations: even some constellations of the northern half of the sky could have been used in this method of time-keeping. The references to the observational practices of the hour-watchers are scarce and

known mostly from late period sources such as the inscription on a statue depicting the astronomer Harkhebi and a sighting instrument with inscriptions mentioning an astronomer named Hor (Clagett 1995) and (Pries 2010). However, it is safe to say that such practices existed throughout Pharaonic history. The observing conditions of the hour-watchers were rather ideal, with about 300 clear nights each year (Mikhail and Haubold 1995).

Algol is the 60th brightest star in the sky (Hoffleit and Jaschek 1991). At the latitude of Middle Egypt, $\phi_{\text{Earth}} = 26.6^\circ$, the never setting circumpolar stars have declinations $\delta_{\text{Star}} > 90^\circ - \phi_{\text{Earth}} = 63.4^\circ$. The declinations of stars that never rise above horizon are $\delta_{\text{Star}} < \phi_{\text{Earth}} - 90^\circ = -63.4^\circ$. Circumpolar stars are not ideal hour-stars, because they never rise or set. Furthermore, their angular motion within a limited area around the celestial pole is not ideal for measuring time. It is not easy to obtain accurate timing from the minor changes in their positions. Stars below horizon can certainly not be used as hour-stars. If the circumpolar stars and the stars below horizon are excluded, Algol was the 56th brightest star at $\phi_{\text{Earth}} = 26.6^\circ$ in 1224 B.C. However, if a star culminates in the south below an altitude of $\alpha = 10^\circ$, its brightness decreases about one magnitude due to atmospheric extinction and it can be observed only for a short time even in ideal observing conditions. Such a star is not a suitable hour-star. A star that sets 10° (or less) below horizon in the north is neither an ideal hour-star, because it rises and sets nearly at the same location, and its brightness decreases close to the horizon due to extinction. Using the limits $-53.4^\circ < \delta_{\text{Star}} < 53.4^\circ$, makes Algol the 51st brightest star in the Middle Egyptian sky in 1224 B.C. These declination limits of ours are conservative, because many other stars culminating in the north are useless for time keeping, and extinction influences the comparison of the brightness levels between Algol and the stars always remaining close to the horizon. This raises Algol much higher than the 51st best in the list of suitable bright hour-stars (FAQ 7).

Algol’s equatorial coordinates were right ascension $\alpha_{\text{Algol}} = 1^\circ$ and declination $\delta_{\text{Algol}} = 25^\circ$ in 1224 B.C. which gives the following ecliptic coordinates, longitude $\lambda_{\text{Algol}} = 11^\circ$ and latitude $\beta_{\text{Algol}} = 22^\circ$. The ancient cultures used the latter coordinate system based on the yearly motion of the Sun. Algol was located very close to the vernal equinox and this ecliptic plane. If the timing observations were made towards south, then the bright stars in the ecliptic plane were the most suitable hour-star candidates (Clagett 1995), (Wells 2001b) and (Böker 1984). This location of Algol in the sky raises it very high in the list of suitable bright hour-stars (FAQ 7). Furthermore, Algol culmi-

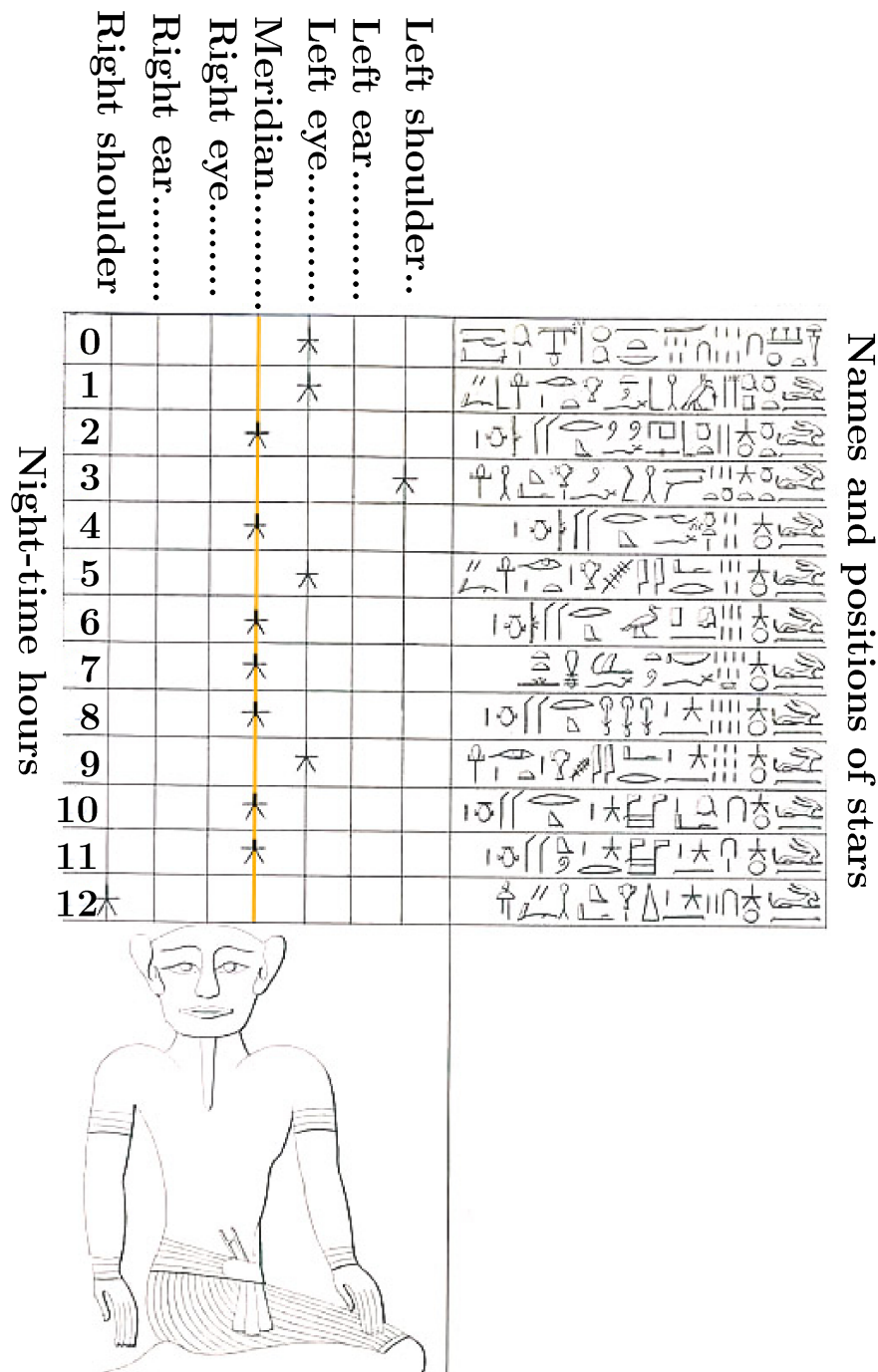


Figure 5. Hour-watcher with a star chart from the tomb of Ramesses VI, 12th century BC. “Meridian” is “opposite the heart” mentioned in Sect. 4.1. Reprinted under a CC BY license @eng.wikipedia.org.

nated at the altitude of $\alpha = 88^\circ$, and this made it an ideal star for measuring time.

One modern hour equals 15 degrees in the equatorial plane, and therefore the required minimum number of hour-stars for covering the entire sky is at least 24. The earliest known star clock scheme, the so-called diagonal

star clock, describes 36 decans (Leitz and Thissen 1995). For a ten-day week, 12 of the decans are tabulated marking the beginnings and ends of the hours. Because the sidereal day is about four minutes shorter than the solar day, these stars reach their positions four minutes earlier every consecutive night. After ten days the stars occupy their

positions about 39 minutes earlier, so in the tabulation of decans for the next week each of the stars "works" one hour earlier. The concept of the hour was relative as its beginning was allowed to fluctuate about 35 minutes by the end of each week. The later Ramesside star clocks are comprised of a system of 46 individual stars observed in positions such as "upon the right shoulder", "upon the right ear", etc. as in our Figure 5 (Leitz and Thissen 1995). These positions were intended for better accuracy but the known tables were given for 15-day periods, where the timing of the hours fluctuated even 55 minutes. However, this model seems to have been outdated by the time it was used in the decoration of Ramesside tombs, so the later developments of the system remain unknown (Leitz and Thissen 1995).

No-one can recognize a single hour-star in the sky without comparing its position to the positions of other bright stars in its vicinity. For the sake of consistency, we introduce our own precise concept: "hour-star pattern". Such a pattern contains one hour-star used by the scribes, and all bright stars that they used to identify this hour-star. Using only two stars per one hour-star pattern would not have provided any recognizable pattern. Therefore, the number of stars per each hour-star pattern must have been at least three, or probably more. This means that the Ancient Egyptians must have observed at least $24 \times 3 = 72$ bright stars, and in this case the visual brightness of the 72th brightest star was about $2.^m5$ in 1240 B.C. Thus, it is certain that the 51st brightest star Algol ($2.^m12$) with an ideal position in the night sky was included into some hour-star pattern (FAQ 7). The names of hour-stars in the Ramesside star clocks include for example various different body parts and equipment of the Giant, the Bird and the Hippopotamus, suggesting that the stars were members of a known constellation (i.e. an hour-star pattern). According to Belmonte et al. (2009), a complete set of constellations formed the Egyptian celestial diagram, i.e. every star belonged to some constellation.

Unlike Astronomy, Egyptology is not an exact science and few questions can be answered with absolute certainty. For our ten arguments I-X presented in Sects. 4.1-4.10 it is not important if Algol was an actual hour-star or only a member of some hour-star pattern or related constellation (FAQ 7). Algol has not yet been unambiguously identified in any hour-star lists because only the names of Sirius, Orion and the Plough have reached a widespread consensus among egyptologists. Algol (β Persei) is the second brightest star in the modern constellation of Perseus. Egyptologists have presented their own differing identifications of the represented stars with actual stars so it is difficult to say which decan or group would have included Algol (Belmonte et al. 2009), (Böker 1984) and (Conman

2003). Lull and Belmonte (2009, p157-158) claim to have uncovered nearly three quarters of the Egyptian firmament by deciphering the star names of aforementioned tomb of Senenmut, the clepsydra (water clock) of Amenhotep III and the circular zodiac of the temple of Hathor at Dendera, which is from Late Period and already incorporates Mesopotamian and Greek influences. According to them, the ancient Egyptian constellation of the Bird includes the modern constellations Triangulum and Perseus but there is no precise identification of the individual stars of the Bird. Böker (1984) suggested that the correct reading for the decan Khentu, a group of three stars, is the "snorting one"[▲]. The decan is later depicted as a red-haired warrior with fierce attributes reminiscent of Perseus in Greek mythology. The decan is also known as "the lower Khentu"[▲], and mentioned in the decan lists of the Astro-nomical ceiling of the tomb of Senenmut (ca. 1473 B.C.), tomb of Seti I (1313-1292 B.C.) and the Osireion, a temple in Abydos dated to the time of Seti I (Neugebauer and Parker 1960).

The number seven seems to carry plenty of mythological connotations for the Egyptians, such as the seven failed attempts of "Seth" to lift the foreleg into the heavens (Leitz 1994). It is reminiscent of the various names of the Pleiades, a distinct open cluster of bright stars located near Perseus (i.e. Algol), known for example as Seven Sisters, Starry Seven and Seven Dovelets (Allen 1899). Pleiades may have been connected to the "Followers" or the "Ennead" which were both connected to P_{Algol} in CC (Jetsu and Porceddu 2015).

A list of decan deities in papyrus Carlsberg I mentions certain stars that cause "sickness"[▲] in fish and birds, while CC speaks of "a star with bitterness in its face". According to Leitz (1994), "bitterness"[▲] is the name of a sickness that plagued the Egyptians. Decans in the inscription 406 of the temple of Esna are portents of death to the "rebel" (von Lieven 2000). Thus, even without knowing which stars exactly they referred to in these passages, we may conclude that the ancient Egyptians strongly believed in stars influencing the lives of men.

Argument I: For thousands of years, the "hour-watchers" practiced the tradition of timekeeping by observing hour-stars. If Algol was not an hour-star, it certainly belonged to some hour-star pattern or related constellation.

4.2 Crucial timing of nightly rituals

Proper timing was considered crucial for the efficacy of nightly religious rituals.

Astronomy is often considered to be one of the oldest sciences practiced by mankind despite ancient star observing being carried out for the benefit of religious practices. Babylonians were probably the first people to make systematic notes of the Moon and the planets and also to perform calculations of their celestial motions. As opposed to this, ancient Egyptian records that span three millennia are almost obsolete in any quantitative approach despite the culture's special attention to the Sun, the Moon, the planets and the stars as divine entities (Neugebauer 1951). The phases of the Moon and the heliacal rising of Sirius played a part in determining the date and time of New Year and several other important festivals.

In ancient Egypt, the scribal professions were the most valued ones, as the entire functioning of the highly developed culture and state with its complex bureaucracy was based on written communication (Shaw 2012). Many of the professional scribes had several titles emphasizing their specialized knowledge (Clagett 1989), such as “physician”[▲], “healer”[▲], “hour-watcher” (astronomer who observed stars for timekeeping purposes) and “mathematician”[▲].

Beside the religious background, the scribes had plenty of social, political and personal motivation to perform their job with utmost expertise. Many scribes received the title of “king's favourite” during their lifetime and such persons were among the most high ranking members of the Egyptian society (Clagett 1989).

What would have been the ancient Egyptian scribes' interest in the behaviour of a variable star? Knowing the period and the phase of the Moon was important for regulating the religious festivities but the scribes would also have paid attention to any unexpected changes in the observed hour-star patterns. The hour-watchers' activity required the mapping and measuring of the heliacal rising and setting, as well as the meridian transit of stars (Magli 2013). The average width for a suitable ancient Egyptian hour-star pattern would have been about one hour in modern right ascension, *i.e.* 15 degrees. Thus, during every year, Algol's hour-star pattern determined the beginning of the night during half a month ($\sim 15^\circ/360^\circ$), the epoch of midnight during another half a month, and the end of the night during yet another half a month. During thousands of years of timing observations, the discovery of Algol's variability would have been most probable during these particular time intervals of every year (FAQ 7).

It is essential to note that the professional class of scribes was responsible for *both* astronomical observations and religious traditions. To be involved in the science of Astronomy (*e.g.* hour-watching) was also to be involved in the priesthood (*e.g.* nightly rituals) (Shaw 2012).

To properly observe the ritual cycle and recite the magical words at the exactly right time was of foremost importance to the Egyptian priests, since it was a matter of life and death (Assmann and Lorton 2001). The hour-stars were used for this exact timing that was crucial for keeping cosmic order (Clagett 1989) and (Magli 2013). During the night, the Sun was considered to sail across the underworld where the prayers or incantations of the priests opened the gates of the underworld and appeased the terrible guardians of the gates (Wiebach-Koepke 2007). If everything went absolutely right, the Sun was reborn on the 12:th hour of the night. Any failure by the priests in observing the nightly rituals would mean running a risk of the Sun not rising the next morning (Assmann and Lorton 2001).

The consequential purpose of astronomical observations was “religious astronomy” (von Lieven 2000). Any unpredictable change in the hour-star patterns observed by the scribes would have been a shock. The ritual activity of the ancient Egyptian priesthood functioned for the very purpose of maintaining the known universe in a stable condition in order not to plunge into chaos. They needed to use all their resources to keep “Maat”[▲], the cosmic order (Magli 2013). If they found out that a star is variable in brightness, observing its cycle would most certainly have gained their extra attention and intellectual effort.

Argument II: Proper timing of the nightly religious rituals relied on the fixed hour-star patterns.

4.3 Constellation change

Any unpredictable change in the fixed and known hour-star patterns would have been alarming. A naked eye observer witnesses a radical hour-star pattern change during Algol's eclipse.

The naked human eye can detect brightness differences of 0.1 magnitudes in ideal observing conditions. Hence, naked eye eclipse detection is theoretically possible for 7 hours when Algol is more than 0.1 magnitudes dimmer than its brightest suitable comparison star γ Andromedae (see Jetsu *et al.* 2013, their Figure 5a). For 3 hours, Algol is also dimmer than its other five suitable comparison stars ζ Persei, η Persei, ν Persei, δ Persei and β Trianguli. The detection of Algol's eclipse is easy during this 3 hour time interval.

With $P_{\text{Algol}} = 2.850 = 57/20$ days, these opportunities for easy detection follow the sequence of “3+3+13=19” days (Jetsu and Porceddu 2015). A plausible hypothesis is that the ancient Egyptians first discovered the variability of Algol, like Montanari did in 1669, when they were ob-

serving Algol's hour-star pattern. During primary eclipses, Algol lost its brightness gradually for five hours until it was outshined by its six dimmer nearby comparison stars. The dimming was followed by a brightening that lasted for another five hours. This entire 10 hour eclipse event could be observed during a single night, but that was rare event, because it occurred only every 19th night. Algol's hour-star pattern change was so noticeable that the priests on duty as hour-watchers could hardly have missed this event. For the hour-watchers, it would have been useful to communicate among themselves the knowledge about the strange behavior of this hour-star pattern and there is a good possibility, considering the diligent scribe mentality of Egyptian officials, that they would have made written notes about the times of the eclipses.

The modern constellation of Perseus is one of the easiest to perceive. It occupied a prominent position high in the ancient Egyptian night sky, because the maximum altitude of Algol was 88 degrees. Algol is the brightest member of another ancient constellation of four stars which was already recognized by authors like Vitruvius (Vitruvius and Morgan 1960) and Ptolemy (Ptolemy *et al.* 1915). The other three stars are π Per ($4.^m7$), ω Per ($4.^m6$) and ρ Per ($3.^m4 - 4.^m0$). During the primary eclipses, the brightness of Algol falls from $2.^m1$ to $3.^m4$, *i.e.* these other three stars never appear to be brighter than Algol. The shape of this constellation resembles a diamond and it was therefore called the Head of Gorgon or the Head of Medusa (Allen 1899) in the Hellenistic culture. The angular separation between Algol and the other three stars is less than two degrees, and this constellation is therefore ideal for detecting variability because atmospheric extinction does not mislead brightness comparisons even at low altitudes close to the horizon. At its brightest, Algol visually dominates this diamond shaped constellation, because it is clearly much brighter than the other three stars. Hence, a naked eye observer can easily notice the significant constellation pattern change during Algol's eclipse. Wilk (1996) suggested that from this may have arisen the myth of the Medusa losing its head.

In principle, other variable stars besides Algol, like the disappearing and reappearing Mira, also called Omicron Ceti, might also have been discovered by the ancient Egyptians. However, the eleven month period of Mira is so long that it can not be rediscovered with statistical methods in CC (Jetsu *et al.* 2013, p9, see Criterion C_2).

Argument III: A naked eye can easily discover the significant hour-star pattern change caused by Algol's eclipse.

4.4 “3+3+13=19” and “19+19+19=57” days eclipse rules

Algol's night-time eclipses followed the regular 3+3+13=19 and 19+19+19=57 days cycles with $P_{\text{Algol}} = 2.850 = 57/20$ days. (Jetsu and Porceddu 2015).

If an eclipse first occurred in the end of the night, then after three days the next eclipse occurred close to midnight. After another three days the next eclipse occurred in the beginning of the night. After these three eclipses, it took thirteen days, before the next eclipse was observed, *i.e.* the first eclipse in the end of the night was repeated again (Jetsu and Porceddu 2015). This is the “3+3+13=19” days rule, *i.e.* a sequence of three night-time eclipses was repeated every 19 days. The midnight eclipses, when both the dimming and the brightening of Algol could be observed during the same night, occurred at 19 days intervals. Coincidence or not, the CC prognosis of the first day of every month is GGG and the prognosis of the 20th day of every month is SSS. These two particular days of every month are separated by the “3+3+13=19” days eclipse cycle.

With the period of $P_{\text{Algol}} = 2.850 = 57/20$, eclipses separated by 57 days would have occurred at exactly the same time of the night. This is the “19+19+19=57” days rule, *i.e.* this entire 57 days eclipse sequence kept on repeating itself over and over again. For this reason, there are only 20 small blue or red circles (night-time or daytime eclipses) in Figure 6a, although this figure shows all 126 eclipses occurring during 360 days. If the hour-watchers began to make notes of the eclipse epochs, the “3+3+13=19” days eclipse cycle would have been discovered first, then later the “19+19+19=57” days eclipse cycle. The first regularity is easier to discover, because all Algol's night-time eclipses follow this “3+3+13=19” cycle with $P_{\text{Algol}} = 2.850 = 57/20$ days. The second cycle of “19+19+19=57” days is more difficult to discover, because it requires the measurement of the nightly shifts of these night-time eclipses within the “3+3+13=19” cycle. Although the ancient Egyptians had no way of knowing that Algol's eclipses also happened during daytime, their long-term eclipse records may have eventually led to the discovery of this 57/20 days ratio.

Simulations have shown that modern period analysis would rediscover the 2.850 days period in CC, if the scribes had recorded nearly all observed night-time eclipses (Jetsu *et al.* 2013). The fact that the 19 days period is also present in these data (Jetsu *et al.* 2013) confirms that *only* the night-time eclipses were used in the construction of CC. This result can be deduced from Figure 6a. It is highly unlikely that the ancient Egyptians knew that Algol's eclipses also occurred at daytime, because these events could not be observed. If an eclipse occurred at the daytime, then no

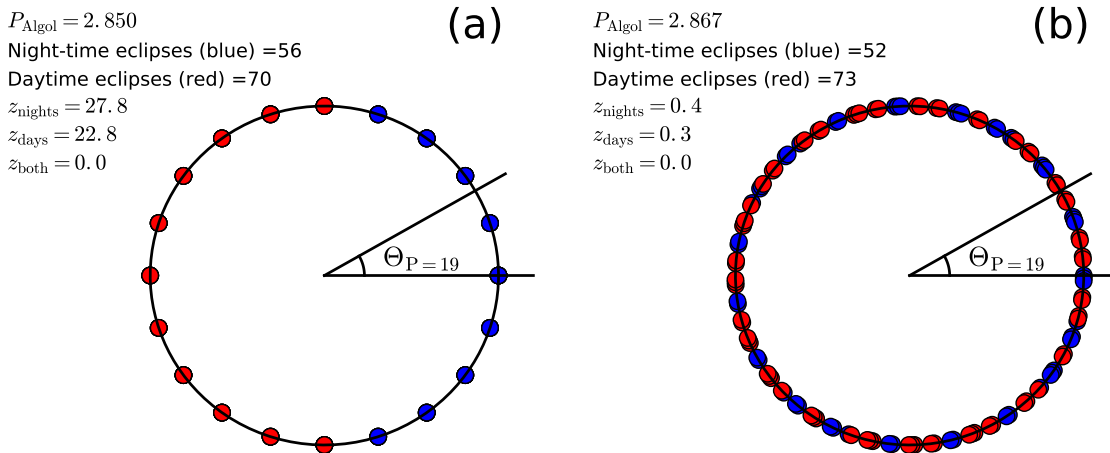


Figure 6. Mid-epochs of Algol's primary eclipses. (a) The yearly mid-epochs of 56 night-time eclipses occurring ± 5 hours at both sides of midnight with the period $P_{\text{Algol}} = 2.850$ days (blue circles). The red circles denote the 70 daytime eclipses. Note that only 20 circles are visible, because the 56 red or 70 blue circles overlap. The eclipse phase angles $\Theta_{P=19}$ are computed for the period $P = 19$ days. The values of the Rayleigh test statistic for these eclipse epoch time points with $P = 19$ days (Jetsu and Porceddu 2015, z in Eq. 7) are given for the night-time eclipses (z_{nights}), the daytime eclipses (z_{days}) and all eclipses (z_{both}). (b) The same as in (a), except that the current period value, $P_{\text{Algol}} = 2.867$ days, is used.

eclipse was observed on the previous night or the next night. However, this absence of night-time eclipses could be observed. This absence was observed in 16 nights of every 19 days cycle. Our Figure 6a shows that there are two plausible alternatives that exclude each other. Either the *presence* (Figure 6a: $z_{\text{nights}} = 27.8$) or *absence* (Figure 6a: $z_{\text{days}} = 22.8$) of night-time eclipses was used as a criterion for selecting the lucky prognoses connected to Algol's variability. In other words, if the ancient Egyptians had used *both* the night-time and the daytime eclipses in the construction of CC, this would have erased the 19 days signal completely away from CC (Figure 6a: $z_{\text{both}} = 0.0$). The alternative that the absence of night-time eclipses was used in assigning lucky prognoses is more probable, because the lucky prognoses mentioning “Horus”, “Sakhmet” and “Wedjat” concentrate on the bright phases of Algol (Figure 1). This alternative is later discussed in greater detail in Sect. 4.8 (principle I).

The scribes seem to have applied a very accurate value for the synodic period of the Moon, 29.6 days, to correctly predict the lunar phases (Jetsu *et al.* 2013). If they intended a correct prediction of Algol's eclipses they would have also needed an accurate period value. Our Figure 6b shows how the “3+3+16=19” days cycle breaks down with the currently observed 2.867 days period of Algol. Modern period analysis detects the 19 days and the 2.850 days periods in CC, but it does not detect the current 2.867 days period of Algol (Jetsu *et al.* 2013). Our Figure 6b confirms that if the period of Algol in those days had been the same as

the current period, 2.867 days, there would be no signs of the 19 days period in CC ($z_{\text{nights}} = 0.4$, $z_{\text{days}} = 0.3$ and $z_{\text{both}} = 0.0$).

Argument IV: The scribes could have discovered Algol's $2.850 = 57/20$ days period from long-term observations of the regular 19 and 57 days eclipse cycles.

4.5 Ancient Babylonian and Chinese lunar eclipse prediction

The ancient Egyptian discovery of $2.850 = 57/20$ days ratio in Algol's eclipses would resemble the ancient Babylonian and Chinese discoveries of the lunar eclipse cycle. Here, we discuss *how* these two analogous ancient astronomical cycle discoveries were made, and *how* the ancient Egyptians may have utilized a similar approach to observe Algol's variability.

Firstly, the process that may have lead to the ancient Egyptian discovery of the periodicity of Algol's eclipses could have been analogous to the process which led to the ancient Babylonian detection of the cycle in the lunar eclipses. The unexpected occurrence of solar and lunar eclipses must have deeply impressed ancient civilizations. The motivation for prognostications was obvious. There is a description of how the Babylonians determined the Saros cycle, 18 years and 11.33 days, in the occurrence of lunar eclipses (Pannekoek 1989). Detailed long-term records were kept of these events. Somewhere between 750 and 650 B.C. there was a more or less complete record of the

observed eclipses and by fairly basic analysis it was found out that within 223 lunar months there were 38 eclipse possibilities. Also these phenomena always occurred in a series of four, five or six consecutive lunar eclipses. A theory of the past and future lunar eclipses, which was based on the table called “Saros-Canon”, emerged sometimes after 280 B.C. Brack-Bernsen and Steele (2005) have argued that the Babylonians may even have invented sophisticated methods to determine the anomalies (between 6 and 9 hours) of the Saros cycle. Ancient Egyptians were also fluent in arithmetic and geometric calculations and devised plenty of tabulations to aid in practical life (Clagett 1999) and (Rossi 2004). Papyrus Carlsberg 9 reveals that they used long-term observations to determine the correct period of the Moon (Clagett 1995). It has also been shown that the P_{Moon} value in CC was so accurate it must have been determined from observations made over more than one year (Jetsu *et al.* 2013). These two cases (Jetsu *et al.* 2013; Clagett 1995) confirm that the ancient Egyptians were capable of using long-term observations to determine the periods of celestial objects. By the Late Period, the Egyptians were also familiar with the use of the Saros cycle of 223 synodic months to predict lunar and solar eclipses. Ptolemy’s commentators referred to these periods as having been used already by “the ancients” (Steele 2000).

Secondly, at about 400 B.C. the Chinese were using an astronomical calendar to predict the dates of lunar eclipses (Steele 2000). This calendar made use of a cycle of 135 months which includes 23 lunar eclipse possibilities. They approximated that eclipse possibilities occur periodically every 5 and 20/23 months and counted them arithmetically. The ancient Egyptians could have used an analogous approach to Algol’s eclipses.

The alternating period changes of Algol are so small (Biermann and Hall 1973) that they do not mislead long-term period determination based on naked eye observations. However, the synodic period of the Moon varies between 29.3 and 29.8 days in a year (Stephenson and Baolin 1991). Thus, Algol’s eclipses are far easier to predict than lunar eclipses, because Algol’s period is constant, while that of the Moon is not. The $2.850 = 57/20$ days ratio means that 20 eclipses of Algol occur during *every* 57 days cycle (Figure 6a). If the scribes performed long-term observations of these cycles, these observations would have eventually revealed that *all* nine Algol’s night-time eclipses could *always* be observed within *every* 57 days cycle.

There are three alternative methods of *how* the period of 2.850 days ended up into CC. We may never find out which one of these three methods was used. However, in every alternative the scribes would have discovered the eclipses of Algol, and recorded the period of these events.

1st method: The scribes might have calculated the numerical value $P_{\text{Algol}} = 2.850$ days from long-term observations.

2nd method: The scribes may not have had any reason for even trying to calculate the actual period. If they noticed that Algol’s three consecutive night-time eclipses followed the 19 days cycle, while nine consecutive night-time eclipses occurred in every $19+19+19=57$ days cycle, these cycles would have appeared extremely stable over very long periods of time. The minor nightly shifts in the epochs of the eclipses within individual 19 days cycles cancelled out within every 57 days cycle. The scribes may not even have noticed these minor nightly shifts within individual 19 days cycles, because the eclipses at the end of the night, close to the midnight or at the beginning of the night always returned back exactly to the same moments of night after every 57 days cycle. If the real period of Algol was $57/20=2.850$ days, these 19 and 57 days cycles would have enabled the scribes to foretell what would be observed in the sky. While the scribes may have recorded into CC *only* the 19 or 57 days cycles in the night-time eclipses of Algol, modern period analysis confirms that these rules worked perfectly *only if* the real period of Algol was $57/20=2.850$ days in those days. Hence, the scribes have, although only perhaps unknowingly, also recorded the $57/20=2.850$ days period into CC.

3rd method: The scribes only used the observed epochs of night-time eclipses as such in the construction of CC. This could be achieved even without ever solving a numerical estimate of $P_{\text{Algol}} = 2.850$ days, or without ever discovering the 19 and 57 days cycles. Also in this case, the scribes have unknowingly recorded the $57/20=2.850$ days period into CC.

Argument V: The ancient Egyptian scribes may have calculated the $57/20 = 2.850$ days period of Algol from long-term observations (1st method). They may not have calculated this 2.850 days period, because the 19 days and 57 days cycles already perfectly predicted *all* night-time eclipses of Algol (2nd method), or they may have just recorded the observed night-time eclipses into CC (3rd method).

4.6 Indirect references to protect cosmic order

After the scribes had discovered Algol's variability, it would have been attributed religious significance and described accordingly.

Lack of direct references to Algol's variability in ancient Egyptian records raises questions. We may draw parallels to solar eclipses, which were experienced by Egyptians during the New Kingdom and could not have passed unnoticed. Yet, these events are not mentioned directly in written records (Smith 2012). The first plainly written Egyptian eclipse records are found in the demotic papyri Berlin 13147 + 13146 which date to the first century B.C. (Steele 2000). Smith (2012) interpreted references to solar eclipse events in New Kingdom texts and concluded that astronomical events were described indirectly by using religious terminology and the reference might even have been made deliberately obscure. In Late Period demotic writings eclipses were mentioned and described as fearsome and unlucky portents (von Lieven 1999).

In general, ancient Egyptian scribes seem to have avoided direct references to celestial events, because writing was considered in itself to have a magical power that allows the scribe to communicate with the gods. This could be the reason why they avoided direct references to the celestial events, *i.e.* the observed actions of divine deities in the sky. The scribes would have avoided making direct textual references to the uncanny behaviour of Algol in order to preserve cosmic order. Divine names that may have been related to Algol are various, depending on the context. In particular, the names "*Horus*", "*Wedjat*" and "*Sakhmet*" had similar phase angle θ_{Algol} distributions in Figures 1 and 2. We conclude that references to astronomical events are indirect but undoubtedly present throughout the whole CC text, not unusual for Egyptian mythological texts in general (Leitz 1994).

Argument VI: To avoid violating cosmic order, the scribes would have referred to Algol's changes only indirectly.

4.7 Two legends

Lists 1 and 2 are given in Appendix C and D, respectively. These lists are full of extracts from two well known legends: "the Destruction of mankind" (hereafter LE1) and "the Contendings of Horus and Seth" (hereafter LE2). CC texts seem to refer to many lesser known legends as well, but most of the extracts on these lists, chosen by the occurrence of the selected SW, are clearly connected to these

two well known legends (for example "peace between Horus and Seth", "pacify the Wedjat"). Those without a clear connection to either of these two such as "Horus hears your words in front of every god" or "Horus is proceeding while Deshret sees his image" could fit into other narratives. However, these are of generic or fragmentary nature and the associations would be too speculative to help to understand the significant periodicity in the prognoses. It is not our ambition here to explain the prognosis of all individual dates but to find the logic behind the periodicity, caused by a larger group of connected dates and prognoses.

4.7.1 Destruction of Mankind (LE1):

In this legend, Re sends the Eye of "*Horus*" (*i.e.* "*Wedjat*") to punish the rebellious mankind.

The legend of the "Destruction of Mankind" is a mythological narrative that figures repetitively in CC. It concerns the Eye of "*Horus*", also called "*Wedjat*" or "The Raging One"[▲] (Leitz and Budde 2003), fighting against the rebels who oppose the Sun god "*Re*". In the beginning of this legend, Re sends auxiliary gods in the form of fishes to overhear the plots of the rebellious mankind (Guilhous 2003). The impudence of mankind causes "*Re*" to send the Eye of "*Horus*" to kill all the rebels. As the Eye takes the form of the lion-goddess "*Sakhmet*", the destruction of the entire mankind is imminent. The gods deceive the goddess "*Sakhmet*" by colouring beer mash with hematite to make it look like human blood. "*Sakhmet*" drinks the beer mash, is pacified and mankind is saved (Lichtheim 1976).

4.7.2 Contendings of Horus and Seth (LE2):

In this legend, Horus and Seth contend for the kingship of Egypt.

Another explicitly quoted legend in CC is the "Contendings of Horus and Seth". After being murdered, the divine ruler "*Osiris*" is in the underworld and the contenders for his office are his son "*Horus*" and his brother "*Seth*", who was responsible for the death of "*Osiris*". The dispute is decided by the council of nine gods called the "*Ennead*", ruled by the Sun god "*Re*". Various contests are ordered for "*Horus*" and "*Seth*" to determine who is the able and rightful ruler of Egypt, "*Horus*" being described as physically weak but clever, "*Seth*" stronger but with limited intelligence. "*Seth*" is defeated and two parallel judgements conclude the myth. The first verdict of the gods is a division of the kingdom between the two, but the second ver-

dict is gods giving “Horus” the entire inheritance of his father “Osiris” (Redford 2001). Due to parallel judgements, the legend ends either to the crowning of both “Horus” and “Seth”, or only of “Horus”.

Argument VII: Even a quick glance on List 1 (Θ_{Algor} order) and List 2 (Θ_{Moon} order) reveals that numerous CC texts are excerpts from the LE1 and LE2 legends.

4.8 Astronomical beliefs behind Lucky and Unlucky Days

The scribes used the LE1 and LE2 legends to describe the phases of Algor and the Moon. Here, we show how the events of LE1 and LE2 appear in Lists 1 or 2. This reveals the three principles that they possibly used to describe celestial variability as activity of deities.

The periods P_{Algor} and P_{Moon} were discovered from over 500 time points of lucky prognoses (Jetsu et al. 2013). These large samples were used to determine the zero epochs t_0 of ephemerides Eq. 5 and 6. The phase angles of lucky prognoses concentrated at these epochs $\Theta_{\text{Algor}} = 0^\circ$ at Aa in Figure 1 and $\Theta_{\text{Moon}} = 0^\circ$ at Ma in Figure 3. This means that these two particular phase angles were considered to be the luckiest in the cycle of Algor and the Moon, respectively.

When the CC passages are read in temporal order from one day to the next, the general sequence of events appears disorganized. However, the contents of the passages begin to make sense when these passages are rearranged and read in the order of increasing Θ_{Algor} and Θ_{Moon} (Lists 1 and 2). This result could have been accomplished even without solving the zero epochs t_0 of Eqs. 5 and 6, because the same stories are repeated in the same phase angle order of Algor and the Moon. In other words, the Θ_{Algor} and Θ_{Moon} order of these CC passages is unambiguous.

The first principle in assigning Lucky and Unlucky Days seems to have been

principle I: *The middle of the bright phases of Algor and the Moon is lucky for mankind.*

For P_{Algor} , point Aa denotes the luckiest phase angle $\Theta_{\text{Algor}} = 0^\circ$ in Figure 1. Out of all 28 SWs studied by Jetsu and Porceddu (2015), the $n = 14$ lucky time points $g(D, M)$ of “Horus” have the strongest amplifying impact on the P_{Algor} signal (Figure 1: closed squares). Twelve of these fourteen values, having $-90^\circ < P_{\text{Algor}} < +90^\circ$, amplify this signal. The closer the phase angle Θ_{Algor} of any $g(D, M)$ is to $\Theta_{\text{Algor}} = 0^\circ$, the more this time point amplifies the P_{Algor} signal. Here are short excerpts from the five lucky “Horus” passages closest to $\Theta_{\text{Algor}} = 0^\circ$

$g(14, 2) \equiv \Theta_{\text{Algor}} = 6^\circ$, “the majesty of Horus receiving the white crown”

$g(19, 12) \equiv \Theta_{\text{Algor}} = 13^\circ$, “this eye of Horus has come, is complete, is uninjured”

$g(27, 1) \equiv \Theta_{\text{Algor}} = 19^\circ$, “Peace between Horus and Seth”

$g(24, 3) \equiv \Theta_{\text{Algor}} = 19^\circ$, “Onnophris’ happiness in giving his throne to his son Horus”

$g(1, 7) \equiv \Theta_{\text{Algor}} = 32^\circ$, “a feast of entering into heaven (i.e. appearing into the sky). The two banks of Horus rejoice”

These texts suggest that the lucky prognoses of “Horus” were connected to the bright phases of Algor (Jetsu and Porceddu 2015).

For P_{Moon} , the luckiest phase angle $\Theta_{\text{Moon}} = 0^\circ$ coincides with point Ma in Figure 3. Leitz (1994) had already argued that the New Moon occurred between the unlucky time points on the first of the following two consecutive days

$s(16, 7) \equiv \Theta_{\text{Moon}} = 173^\circ$, “Opening of the windows and opening of the court. Seeing the portal of the “western side of Thebes”[▲] where his place is. Do not look at the darkness on this day.”

$s(17, 7) \equiv \Theta_{\text{Moon}} = 185^\circ$, (Figure 4: “Seth”) “Do not speak the name of Seth on this day. Who in his lack of knowledge pronounces his name, he will not stop fighting in his house of eternity.”

According to his calculations $s(16, 7)$ was the New Moon day when one is forbidden to go outside and see the darkness. The above two unlucky dates are indeed at both sides of point Mc $\equiv \Theta_{\text{Moon}} = 180^\circ$, and exactly half a lunar cycle away from the luckiest phase at Ma. This result for the phase angle of the New Moon, $Mc \equiv \Theta_{\text{Moon}} = 180^\circ$, suggests that the epoch t_0 of our ephemeris of Eq. 6 is correct. Hence, the Full Moon is at $Ma \equiv \Theta_{\text{Moon}} = 0^\circ$.

The lucky time points $g(D, M)$ having phase angles Θ_{Moon} close to $\Theta_{\text{Moon}} = 0^\circ$ amplify the P_{Moon} signal. The lucky points of “Earth” and “Heaven” have the strongest impact on the P_{Moon} signal (Jetsu and Porceddu 2015).

There are only three lucky time points that mention both “Horus” and “Seth” during the same day (Figure 3: dark squares and open triangles. Note that the “Horus” and “Seth” texts at $\Theta_{\text{Moon}} = 73^\circ$ in List 2 are from two different days). The excerpts of these three days are

$g(27, 1) \equiv \Theta_{\text{Algor}} = 19^\circ, \Theta_{\text{Moon}} = 278^\circ$, “Peace between Horus and Seth”

$g(27, 3) \equiv \Theta_{\text{Algor}} = 38^\circ, \Theta_{\text{Moon}} = 287^\circ$, “Judgement between Horus and Seth. Stopping the fight”

$g(29, 3) \equiv \Theta_{\text{Algol}} = 291^\circ$, $\Theta_{\text{Moon}} = 312^\circ$, “*The white crown is given to Horus and the red one to Seth*”

In all these three cases, Algol is also at its brightest and the Moon is waxing gibbous, since half moon had occurred at phase angle $\text{Md} \equiv \Theta_{\text{Moon}} = 270^\circ$. These texts suggest the reconciliation of the two gods, “Horus” and “Seth”, thus peace in Egypt and lucky days, when Algol and Moon were simultaneously bright. The White Crown (Hedjet) represented the kingship of Upper Egypt and the Red Crown (Deshret) the rulership of Lower Egypt (Goebs 2001).

We know from an unrelated text from Edfu that “Horus” would benefit from the brightening of the Moon: “*When he completes the half month, he assumes control of the sky rejuvenated*” (Kaper 2001). The CC text

$s(26, 2) \equiv \Theta_{\text{Moon}} = 270^\circ$, “*Do not lay the foundation of a house. Do not stock a workshop. Do not order any job. Do not do any work on this day. It is day of opening and closing the court and the windows of Busiris.*”

coincides with $\text{Md} \equiv \Theta_{\text{Moon}} = 270^\circ$, the first-quarter moon.

At the moment of Full Moon, “Horus” was declared “true of voice” and “joyful”; related to his victory over “Seth” in the divine tribunal (Kaper 2001). The unlucky prognoses of “Seth” also show a connection to P_{Moon} , especially to the darker phases of Moon (Figure 4: open triangles).

The only lucky time point of “Horus” overlapping the thick curved line in Figure 1 (Algol’s primary eclipse), mentions

$g(28, 3) \equiv \Theta_{\text{Moon}} = 164^\circ$, “*The gods are in jubilation and in joy over the making of will for Horus*”

it refers to the will made by “Osiris” that raises “Horus” to be the ruler of Egypt. Because of this we can not say that the dark phase of Algol would be always unlucky. However, unlucky days follow *immediately after* Algol’s eclipse because the regular distribution of unlucky time points $s(D, M)$ of “Horus”, “Wedjat” and “Sakhmet” concentrates at $\Theta_{\text{Algol}} = 270^\circ$ (Figure 2).

The “second principle in assigning Lucky and Unlucky Days” probably was

principle II: *Use elements from LE1 and LE2 to indirectly describe Algol’s changes (List 1).*

List 1 contains the translated full CC passages mentioning “Horus”, “Wedjat” and “Sakhmet”. The short excerpts below give a compact presentation of these passages. We indicate the cases with a clear connection to LE1

or LE2. Our notation “NC” means that there is no clear connection specifically to either myth.

$g(14, 2) \equiv \Theta_{\text{Algol}} = 6^\circ$ (Figure 1: “Horus”) “*Horus receiving the white crown*” (LE2)

$s(5, 8) \equiv \Theta_{\text{Algol}} = 6^\circ$ (Figure 2: “Horus”) “*Horus is proceeding while Deshret sees his image*” (NC)

$g(1, 5) \equiv \Theta_{\text{Algol}} = 13^\circ$ (Figure 1: “Wedjat”, “Sakhmet”) “*Re ... Sakhmet, ... pacify the Wedjat*” (LE1)

$g(19, 12) \equiv \Theta_{\text{Algol}} = 13^\circ$ (Figure 1: “Horus”) “*This eye of Horus has come, is complete, is uninjured*” (LE1)

$g(27, 1) \equiv \Theta_{\text{Algol}} = 19^\circ$ (Figure 1: “Horus”) “*Peace between Horus and Seth*” (LE2)

$g(24, 3) \equiv \Theta_{\text{Algol}} = 19^\circ$ (Figure 1: “Horus”) “*giving his throne to his son Horus*” (LE2)

$g(1, 7) \equiv \Theta_{\text{Algol}} = 32^\circ$ (Figure 1: “Horus”) “*entering into heaven. The two banks of Horus rejoice*” (NC)

$g(27, 3) \equiv \Theta_{\text{Algol}} = 38^\circ$ (Figure 1: “Horus”) “*Judgement between Horus and Seth. Stopping the fight*” (LE2)

$g(15, 11) \equiv \Theta_{\text{Algol}} = 38^\circ$ (Figure 1: “Horus”) “*Horus hears your words in front of every god*” (NC)

$g(1, 9) \equiv \Theta_{\text{Algol}} = 51^\circ$ (Figure 1: “Horus”) “*Feast of Horus, the son of Isis*” (NC)

$g(3, 2) \equiv \Theta_{\text{Algol}} = 57^\circ$ (Figure 1: “Wedjat”) “*Re ... gave the inscription of pacification of Wedjat-eye*” (LE1)

$g(7, 9) \equiv \Theta_{\text{Algol}} = 88^\circ$ (Figure 1: “Horus”) “*followers of Horus ... in the foreign land*” (LE1 or LE2)

$g(28, 3) \equiv \Theta_{\text{Algol}} = 164^\circ$ (Figure 1: “Horus”) “*the making of will for Horus*” (LE1 or LE2)

$g(1, 10) \equiv \Theta_{\text{Algol}} = 240^\circ$ (Figure 1: “Horus”) “*Horus... Osiris... Chentehtai... Land*” (NC)

$s(26, 1) \equiv \Theta_{\text{Algol}} = 253^\circ$ (Figure 2: “Horus”) “*day of fighting between Horus and Seth*” (LE2)

$s(11, 11) \equiv \Theta_{\text{Algol}} = 253^\circ$ (Figure 2: “Horus”) “*the eye of Horus raging in front of Re*” (LE1)

$s(10, 6) \equiv \Theta_{\text{Algol}} = 259^\circ$ (Figure 2: “Wedjat”) “*coming forth of Wedjat*” (LE1)

$s(27, 8) \equiv \Theta_{\text{Algol}} = 265^\circ$ (Figure 2: “Sakhmet”) “*majesty of Sakhmet violates*” (LE1)

$g(16, 4) \equiv \Theta_{\text{Algol}} = 278^\circ$ (Figure 1: “Sakhmet”) “*day of the feast of Sakhmet and Bastet*” (NC)

$s(13, 6) \equiv \Theta_{\text{Algol}} = 278^\circ$ (Figure 2: “Sakhmet”) “*arrival of Sakhmet ... “slaughterer-demons”... loose*” (NC)

$s(7, 10) \equiv \Theta_{\text{Algol}} = 278^\circ$ (Figure 2: “Sakhmet”) “*“slaughterer-demons”[▲] of Sakhmet*” (NC)

$g(23, 7) \equiv \Theta_{\text{Algol}} = 291^\circ$ (Figure 1: “Horus”) “*Feast of Horus in Athribis*” (NC)

- $g(29, 3) \equiv \Theta_{\text{Algor}} = 291^\circ$ (Figure 1: “Horus”) “white crown is given to Horus ... red one to Seth” (LE2)
- $s(20, 9) \equiv \Theta_{\text{Algor}} = 291^\circ$ (Figure 2: “Horus”) “*angered on the island ... inspected by ... Horus.*” (NC)
- $g(9, 5) \equiv \Theta_{\text{Algor}} = 303^\circ$ (Figure 1: “Sakhmet”) “*gods are joyful over the matter of Sakhmet*” (LE1)
- $g(30, 10) \equiv \Theta_{\text{Algor}} = 303^\circ$ (Figure 1: “Wedjat”) “*coming forth of Shu to bring back Wedjat*” (LE1)
- $g(29, 5) \equiv \Theta_{\text{Algor}} = 309^\circ$ (Figure 1: “Sakhmet”) “*sole mistress Sakhmet the great ... gods are pleased*” (NC)
- $g(18, 1) \equiv \Theta_{\text{Algor}} = 322^\circ$ (Figure 1: “Horus”) “*magnifying the majesty of Horus over his brother*” (LE2)
- $g(6, 9) \equiv \Theta_{\text{Algor}} = 322^\circ$ (Figure 1: “Wedjat”) “*they catch Wedjat together with their followers*” (LE1)

The lucky prognoses of the days related to the main protagonists of LE1, “Horus”, “Wedjat” and “Sakhmet”, had a strong impact on the P_{Algor} signal (Jetsu and Porceddu 2015). All time points of these three deities have extremely similar Θ_{Algor} distributions (Figures 1 and 2). The lucky prognoses are centered at Aa at $\Theta_{\text{Algor}} = 0^\circ$ in the middle of the brightest phase of Algor (Figure 1). The unlucky prognoses of these three SWs concentrate close to Ad at $\Theta_{\text{Algor}} = 270^\circ$, immediately after Algor’s eclipse (Figure 2).

The passages between $\Theta_{\text{Algor}} = 6^\circ$ and 51° describe feasts or peaceful actions by “Horus”, “Wedjat” and “Sakhmet”. Those regarding the crowning or judgement of “Horus” are related to LE2. The bringing back of “Wedjat” is related to LE1, as well as the pacifications of “Sakhmet” or “Wedjat”. The only exception is “*Horus is proceeding while Deshret sees his image*” at $\Theta_{\text{Algor}} = 6^\circ$ which might not be directly related to either LE1 or LE2. Notably, this unlucky date close to point Aa is the only unlucky time point that deviates from the other seven unlucky time points concentrated close to Ad in Figure 2.

The text at $\Theta_{\text{Algor}} = 57^\circ$ refers to the order that “Re” gave in LE1 to save mankind from the wrath of “Wedjat” (Eye of “Horus”), synonymous with “Sakhmet”. As Algor’s eclipse is approaching at $\Theta_{\text{Algor}} = 88^\circ$, “Horus” enters “the foreign land” (LE1 or LE2). His “will is written” at $\Theta_{\text{Algor}} = 164^\circ$ (LE1 or LE2). This particular time point $g(28, 3)$ coincides with the moment when Algor’s eclipse can be observed with naked eye (Figure 1: thick curved line at Ac).

The interval between $\Theta_{\text{Algor}} = 253^\circ$ and $\Theta_{\text{Algor}} = 291^\circ$ is filled with descriptions of anger and aggression by “Horus”, “Wedjat” and “Sakhmet”, or contains hostile elements such as the “slaughterer-demons”. These specific demons were believed to punish mankind on behalf of “Sakhmet” and were considered the cause of diseases and symptoms whose pathology was not well understood (Lu-

carelli 2010). Some texts are clearly related to the transformation of “Wedjat” into the raging “Sakhmet” (LE1). Two out of the three prognoses at $\Theta_{\text{Algor}} = 291^\circ$, are lucky. After these three, all remaining texts are lucky, i.e. there are only good prognoses in the end of Algor’s cycle. This suggests the pacification of “Sakhmet”, as in LE1. “The coming forth of Shu to bring back Wedjat” is mentioned at $\Theta_{\text{Algor}} = 303^\circ$ (LE1). “Shu” succeeds in his intention, “they catch Wedjat together with their followers”, at $\Theta_{\text{Algor}} = 322^\circ$ (LE1). Then, the same stories begin anew at $\Theta_{\text{Algor}} = 6^\circ$.

In short, all the texts of “Wedjat” and “Sakhmet” that were not discussed earlier (Jetsu and Porceddu 2015), also support the idea that principle II was used to assign the prognoses of CC. The order of List 1 texts connected to LE1 more or less follows the plot of LE1, but the order of texts connected to LE2 does not follow the plot of LE2. This is not unexpected, because several events are related to “Seth”, who is not connected to the P_{Algor} signal (Jetsu and Porceddu 2015).

The “third principle in assigning Lucky and Unlucky Days” could have been

principle III: Use LE2 for indirect description of the lunar phases (List 2).

The unlucky prognosis texts of “Seth” and “Osiris” support this idea. These prognoses are very clearly concentrated to the dark phases of the Moon (Figure 4: open triangles and closed circles). The descriptions from List 2 are

- $s(12, 2) \equiv \Theta_{\text{Moon}} = 100^\circ$ (Figure 4: “Seth”) “*His head, who did rebel against his lord, is cut off*”
- $s(13, 3) \equiv \Theta_{\text{Moon}} = 117^\circ$ (Figure 4: “Seth” and “Osiris”) “*day of severing*”
- $s(14, 3) \equiv \Theta_{\text{Moon}} = 129^\circ$ (Figure 4: “Osiris”) “*gods are sad over the action against Osiris’ place*”
- $s(11, 12) \equiv \Theta_{\text{Moon}} = 137^\circ$ (Figure 4: “Seth”) “*repelled the confederacy of Seth to the eastern desert*”
- $s(14, 5) \equiv \Theta_{\text{Moon}} = 139^\circ$ (Figure 4: “Osiris”) “*Weeping of Isis and Nephthys*”
- $s(18, 3) \equiv \Theta_{\text{Moon}} = 178^\circ$ (Figure 4: “Seth”) “*tumult by the children of Geb: Seth and his sister Nephthys*”
- $s(17, 7) \equiv \Theta_{\text{Moon}} = 185^\circ$ (Figure 4: “Seth”) “*Do not speak the name of Seth on this day*”
- $s(17, 8) \equiv \Theta_{\text{Moon}} = 190^\circ$ (Figure 4: “Seth”) “*The going of Seth, ... they repelled his followers*”
- $s(19, 4) \equiv \Theta_{\text{Moon}} = 195^\circ$ (Figure 4: “Osiris”) “*Making of ointment for Osiris*”
- $s(20, 2) \equiv \Theta_{\text{Moon}} = 197^\circ$ (Figure 4: “Seth”) “*The rebels against their lord were overthrown*”

- $s(26, 1) \equiv \Theta_{\text{Moon}} = 266^\circ$ (Figure 4: “Horus” and “Seth”) *“day of fighting between Horus and Seth”*
 $s(24, 8) \equiv \Theta_{\text{Moon}} = 275^\circ$ (Figure 4: “Seth”) *“Do not pronounce the name of Seth”*

Seth’s rebellion is first referred to at $\Theta_{\text{Moon}} = 100^\circ$. It is followed by a long story of *“the day of severing”* on $s(13, 3)$. On the next day $s(14, 3)$, *“gods are sad over the action against Osiris’s place”*. “Seth” is repelled in a tumult ($\Theta_{\text{Moon}} = 137^\circ$). The goddesses Isis and Nephthys are mourning the death of “Osiris” ($\Theta_{\text{Moon}} = 139^\circ$). “Seth” causes another tumult ($\Theta_{\text{Moon}} = 178^\circ$). CC advises not to pronounce his name at New Moon ($\Theta_{\text{Moon}} = 185^\circ$). His influence begins to wane ($\Theta_{\text{Moon}} = 190^\circ$). *“Making of ointment for Osiris”* follows at $\Theta_{\text{Moon}} = 195^\circ$. “Seth” is overthrown and judged ($\Theta_{\text{Moon}} = 197^\circ$). Yet, “Seth” and “Horus” continue their fight ($\Theta_{\text{Moon}} = 266^\circ$). In the end, CC advises not to pronounce the name of “Seth” ($\Theta_{\text{Moon}} = 275^\circ$). All these texts are connected *only* to LE2. They mostly follow the plot of LE2 in the order of Θ_{Moon} , but there are contradictions. For example, the beginning of the cycle would be the expected place for the fight at $\Theta_{\text{Moon}} = 266^\circ$.

“Osiris” is also connected to LE2 in the CC. Therefore, it is logical that the unlucky texts of “Osiris” were connected to P_{Moon} (Jetsu and Porceddu 2015).

The three previously discussed lucky prognoses on $g(27, 1)$, $g(27, 3)$ and $g(29, 3)$ mentioning both “Seth” and “Horus” show a reconciliation (LE2) when Algol was at its brightest and the Moon was waxing gibbous after Md ($\Theta_{\text{Moon}} = 270^\circ$).

It would not be logical to study the texts of “Seth” in connection with LE1, since he is not one of the protagonists in the myth. “Horus” personally plays a part only in LE2, but his Eye is a protagonist in LE1. Neither the lucky, nor unlucky, prognoses of “Horus” were connected to P_{Moon} (Jetsu and Porceddu 2015), i.e. they were randomly distributed as a function of Θ_{Moon} (Figures 3 and 4: closed squares).

Because “Horus” is present as a name in both LE1 and LE2, the same texts mentioning “Horus” are repeated when arranged in the order of increasing Θ_{Algol} (List 1) and when arranged in the order of increasing Θ_{Moon} (List 2). This means that we have (or the scribes had) a choice to interpret those texts either in relation to the cycle of Algol or the cycle of the Moon. We do not know if the scribes faithfully repeated always the same mythological texts in relation to the cycle of Algol, the cycle of the Moon or both of these cycles. However, if they did, these “Horus” texts may have a double relation.

The 1st example of a double relation to both Algol and Moon, or to LE1 and LE2, is the text

- $g(28, 3)$ *“The gods are in jubilation and in joy over the making of will for Horus, son of Osiris, to pacify Onnophris in the underworld.”*

At $\Theta_{\text{Algol}} = 164^\circ$, it can describe the return of the lost Eye of Horus during the eclipse of Algol (LE1), but more likely it refers to the will made by “Osiris” that raises “Horus” to be the ruler of Egypt at $\Theta_{\text{Moon}} = 300^\circ$ (LE2). It is also related to the time of gestation and infancy of “Horus”, when he was hidden from enemies’ sight by his mother Isis. All of these three alternative interpretations symbolize the cyclic rejuvenation of royal power over Egypt.

The 2nd example is the text

- $g(7, 9)$ *“The crew and followers of Horus have assembled in the foreign land, to make known that Horus smites him who rebels against his lord.”*

On this day, the phase angles of Algol and the Moon are nearly equal $\Theta_{\text{Algol}} = 88^\circ$ and $\Theta_{\text{Moon}} = 73^\circ$. The smiting of the rebels is equally applicable to punishing the mankind for its wicked ways (LE1) and to the battle against “Seth” with his followers (LE2).

However, only the unlucky texts of “Seth” and “Osiris” clearly follow the principle III, and perhaps the three lucky texts mentioning both “Horus” and “Seth”. Many of the remaining “Horus”, “Seth” or “Osiris” texts may have more complicated connections to LE1 and LE2, or to other myths.

We can confirm principle I which connects the lucky prognoses to the moments in the middle of the bright phases of Algol and the Moon. More tentatively, we present principles II and III, i.e. a specific connection of the LE1 and LE2 myths to the phases of Algol and the Moon. The hemerological tradition had already existed for centuries, if not millennia, and accordingly had accumulated into itself cultural layers from different historical eras. However, this uncertainty in *principles* does not alter our main result that the scribes connected the *texts* of the two legends LE1 and LE2 to the phases of Algol and the Moon.

Argument VIII: The texts of List 1 (Θ_{Algol} order) and List 2 (Θ_{Moon} order) show that the LE1 and LE2 legends could have been used to describe indirectly the regular changes of Algol and the Moon.

4.9 Rejuvenation and kingship

Rejuvenation, the power to disappear and reappear, was associated with “Horus”.

Everything in the ancient Egyptian worldview was repeating in a cyclic manner: the sky, the celestial phenomena, the Nile, the winds, the clouds, the migrating birds and fish, all life in its individual or holistic sense

(Leitz 1994). Even the highest power in Egypt, the divine king, was subject to a continuous cycle, first representing “Horus” on Earth and then “Osiris” in afterlife. The ancient Egyptian deities were subject to the same eternal rules of recurrence.

The discovery of Algol’s variability might have first astonished the scribes. Had the cause of variability been non-repeating, such as supernova, they would have been baffled by it, but it must have been reaffirming to them to notice the regularity of Algol’s variability, well suited to their worldview: the idea of the continuous struggle between the forces of chaos and order (Magli 2013). It must have taken some effort to incorporate this new phenomenon into their religion and mythology, but evidently they were able to do that.

It was probably of utmost importance to the scribes to determine the period of this phenomenon, because this would have allowed them to interpret correctly the divine events relating to it and also to incorporate these events into their explanation of cosmos.

We must remember that the ancient Egyptians did not practice natural sciences in the modern sense, but expressed their worldview and all observable phenomena in the context of religion and myths (von Lieven 2000). Many of their discoveries were known only by the experts of religion and magic, the scribes, who could interpret the indirect mythological descriptions of the observed phenomena. The intention of the writers of CC was not necessarily to prevent outsiders from understanding the connections to Algol and the Moon, but for three millennia their indirect mythological references have hidden from sight the basic periodic principles of assigning Lucky and Unlucky Days (*i.e.* principles I, II and III).

The idea of rejuvenation was important in ancient Egyptian mythology. The Moon was used as a symbol of rejuvenation, called “the one that repeats its form” (Kaper 2001). Likewise, a vanishing and reappearing star would have been suggestive of the restoration of the eye of “Horus” alongside his kingship (Allen 2005), (Edwards 1995) and (Troy 1989), and reaffirming of the Egyptians’ cyclic worldview. The eyes of “Horus” were associated with the crowns of the kings, as symbols of sovereignty (Griffiths 2001). Hence, a regularly variable star would naturally be linked with the divine cycles (“Horus” and his eye), much like the Moon was seen to have rejuvenative power (Kaper 2001). Algol’s eclipses could have been considered the blinding of the eye of “Horus” by “Seth”, but on the other hand the return of the Eye of “Horus” would have reaffirmed the restorative, life-giving powers of the gods and kings of Egypt. “Horus” or his eye are supposed to have been linked with varying celestial objects depending

on the context. Krauss (2016) interpreted the Eye of Horus in CC to be Venus because the narration regarding it can also be taken to mean the yearly absence of Venus from the night sky as it is transformed from a morning star into an evening star. The dramatic changes in the brilliancy of Venus would have been indicative of divine fighting, injuring and rivalry. Additionally, Krauss suggests that the stars called *sehed* in the Pyramid Texts such as Horus are planets because the text attributes to them the ability to move freely but could this also include the ability to vanish from the sky? It is logical that Algol would have been represented in mythological texts as “Horus” or his eye, as were most of the planets in the known Egyptian astronomical texts (Clagett 1995). Considering the significance of the name “Horus” to the periodic signal, the ancient Egyptians could have believed in some connection between Algol, royal power and the cosmic order.

Argument IX: Algol could have been naturally associated with “Horus” and called as such, because Algol can disappear and reappear.

4.10 Astrophysical evidence

The period of Algol must have been shorter three millennia ago (Kwee 1958; Biermann and Hall 1973; Soderhjelm 1975).

It is a fascinating idea that the ancient Egyptians would have discovered Algol’s variability over three thousand years ago, noticed its regularity, determined its period and incorporated this phenomenon into their mythology. Our modern interpretations of their concepts are mostly circumstantial. The interpretation of ancient Egyptian texts is complex when the phenomena are not everyday concrete matters such as agriculture, climate, weather, time keeping, geography or geometry. Although the CC deals with astronomy only indirectly, it contains evidence that the scribes made recordings of a concrete phenomenon later discovered by modern natural science: the regular changes of the eclipsing binary Algol. Several astronomical and astrophysical considerations (Jetsu *et al.* 2013; Jetsu and Porceddu 2015) support the idea that their prolonged naked eye observations revealed the same discoveries of Algol that Montanari (variability) and Goodricke (regular variability) made about three millennia later.

Naked eye can discover regular variability in the Sun, the Moon, the planets and the variable stars. Jetsu *et al.* (2013) formulated eight astronomical criteria which showed that only the periods of the Moon and Algol could be discovered from CC, and it was exactly these two pe-

riods that they rediscovered. Their period analysis also showed that 2.850 days is the strongest real periodicity governing the assignment of the lucky prognoses in CC, after the lucky prognoses connected to the synodic lunar month are removed. The mass transfer from Algol B to Algol A is a well established phenomenon (Soderhjelm 1975; Sarna 1993). This mass transfer should cause a period increase (Kwee 1958; Biermann and Hall 1973). Yet, no-one had confirmed the presence of this phenomenon in over 230 years, since Goodricke determined the period of Algol in 1783. The period of 2.850 days in CC is 0.017 days shorter than the current orbital period of Algol, 2.867 days. The mass transfer between Algol B and A could have caused this period increase during the past three millennia. The required mass transfer rate (Jetsu *et al.* 2013) was in excellent agreement with the predictions of the best evolutionary model of Algol (Sarna 1993). Furthermore, it was shown that Algol's inclination has remained stable (Zavala *et al.* 2010; Baron *et al.* 2012), *i.e.* eclipses occurred also in that historical era and the ancient Egyptians would have been able to record these events (Jetsu *et al.* 2013).

Argument X: Astrophysical considerations support the idea that the 2.850 days period in CC can be the period of Algol.

4.11 Cultural evidence and lack of it

Our arguments prove that the ancient Egyptians *could have* recorded Algol's period into CC, but the very same arguments do not definitively prove that they *did* so. However, such cultural aspects are not important for all of our arguments. We will first discuss the arguments that pose no problems, and then those that do.

There is cultural evidence about the “hour-watchers”, as well as about the connection between their observations and the religious rituals (Arguments I and II). Algol's variability could have been easily observed in any ancient culture, unless the geographical location of this culture prevented observations (Argument III). Many excerpts in List 1 and List 2 are definitively connected to the LE1 and LE2 legends (Argument VII). The order of these excerpts in our Lists 1 and 2 is based on statistical analysis, not on cultural aspects. It is therefore not accidental that this order makes sense (Argument VIII). Statistical, astronomical and astrophysical evidence (Porceddu *et al.* 2008; Jetsu *et al.* 2013; Jetsu and Porceddu 2015) supports our last argument (Argument X).

If the “hour-watchers” noticed Algol's variability and *just* recorded the observed eclipses into CC, then modern period analysis would detect the 2.850 days periodicity

(Arguments IV and V). If the references to Algol and the Moon in CC are indeed indirect, it is, and it will be, very difficult to find any definitive cultural proof about Argument VI. Statistical analysis by Jetsu and Porceddu (2015) has revealed a connection between the 2.850 days period and “Horus”, but our cultural interpretation can be questioned (Argument IX).

We do admit that a specific identification of Algol is missing (FAQ 7) but this is a general problem regarding all but a few stars and planets. The Pyramid Texts make it obvious that Horus is a star, but the identification of the star is a matter of debate. Late Period texts identify Horus-son-of-Isis as god of the morning (mentioned as a star also in Coffin Texts from a much older period, the First Intermediate Period), from which Krauss (2016) concluded that Horus-son-of-Isis and Haroeris (the elder Horus) are Venus as morning star and evening star. This does not exclude other interpretations, particularly since we know that many other celestial objects received the title or association to Horus. Descriptions such as ‘Horus who ascends as gold from upon the lips of the akhet’ (Coffin Texts 255), are applicable to all but circumpolar stars. Krauss analyzed other passages as well from Coffin Texts and the Book of the Dead which prove the association of the Eye of Horus to something else than the Sun or the Moon. It would be worthwhile to also study the celestial diagrams of the Late Period which include Greek and Mesopotamian influences, to discover in greater detail the connection of the Greek constellation of Perseus to the ancient Egyptian star names.

5 Conclusions

We have presented ten arguments which show that the ancient Egyptian scribes, the “hour-watchers”, had the possible means and the motives for recording the period of Algol in CC. Those arguments are combined here.

Argument I: For thousands of years, the “hour-watchers” practiced the tradition of timekeeping by observing hour-stars. If Algol was not an hour-star, it certainly belonged to some hour-star pattern or related constellation.

The scribes observed regularly about 70 bright stars, or most probably a lot more, in a region where there are about 300 clear nights every year. They practiced this tradition for the timing of religious rituals.

Argument II: Proper timing of the nightly religious rituals relied on the fixed hour-star patterns.

The “hour-watchers” probably discovered Algol’s variability from the changes that its eclipses caused in its hour-star pattern.

Argument III: A naked eye can easily discover the significant hour-star pattern change caused by Algol’s eclipse.

These changes followed the regular “3+3+16=19” and “19+19+19=57” days cycles.

Argument IV: The scribes could have discovered Algol’s $2.850 = 57/20$ days period from long-term observations of the regular 19 and 57 days eclipse cycles.

Three alternative methods could have been used in recording the 2.850 days period.

Argument V: The ancient Egyptian scribes may have calculated the $57/20 = 2.850$ days period of Algol from long-term observations (1st method). They may not have calculated this 2.850 days period, because the 19 days and 57 days cycles already perfectly predicted *all* night-time eclipses of Algol (2nd method), or they may have just recorded the observed night-time eclipses into CC (3rd method).

The scribes did not describe Algol’s regular changes directly.

Argument VI: To avoid violating cosmic order, the scribes would have referred to Algol’s changes only indirectly.

Two legends, “the Destruction of Mankind” and “the Contentings of Horus and Seth”, could have been used to indirectly describe the changes of Algol and Moon.

Argument VII: Even a quick glance on List 1 (Θ_{Algol} order) and List 2 (Θ_{Moon} order) reveals that numerous CC texts are excerpts from the LE1 and LE2 legends.

These two legends were probably used to describe celestial phenomena as activity of gods.

Argument VIII: The texts of List 1 (Θ_{Algol} order) and List 2 (Θ_{Moon} order) show that the LE1 and LE2 legends could have been used to describe indirectly the regular changes of Algol and the Moon.

Algol would have been considered as a manifestation of “Horus”.

Argument IX: Algol could have been naturally associated with “Horus” and called as such, because Algol can disappear and reappear.

We have presented evidence that the period of Algol in CC was 0.017 days shorter than today (Porceddu et al. 2008; Jetsu et al. 2013; Jetsu and Porceddu 2015).

Argument X: Astrophysical considerations support the idea that the 2.850 days period in CC can be the period of Algol.

It is not even necessary to present this many arguments to convince the reader that it would be more complicated to explain the statistically significant and accurate 2.850 ± 0.002 days period with something else than Algol. No-one disputes that Algol’s variability is easy to observe. The lack of other reasonable alternatives is also a part of the evidence. It is not only that Algol is the simplest explanation but so far no-one has been able to think of any other reasonable alternative explanation for the 2.850 days periodicity in CC. If no-one can answer our last Frequently Asked Question (Appendix B: FAQ 11), then the following famous aphorism by the Italian Nobel Prize winner Luigi Pirandello must be true: a thing “*is so if it seems so*” (Bentley 1986).

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A List of translations to Ancient Egyptian language

<i>nfr</i>	good
<i>ḥ</i>	bad
<i>ḥt</i>	flood season
<i>prt</i>	winter season
<i>šmw</i>	harvest season
<i>ḥyt</i>	snakes
<i>ḥb</i>	feast
<i>grh</i>	night
<i>rwḥ</i>	evening
<i>ḏd</i>	the djed-pillar
<i>imy-wnwt</i>	hour-watcher
<i>tpt</i>	upper culmination
<i>šn-dwḥt</i>	heliacal setting
<i>mswt</i>	birth (heliacal rising)
<i>hr gḥ wnmy</i>	upon the right shoulder
<i>hr msḏr wnmy</i>	upon the right ear
<i>hr irt wnmy</i>	upon the right eye
<i>r kḥ ib</i>	opposite the heart
<i>hr irt iḥby</i>	upon the left eye
<i>hr msḏr iḥby</i>	upon the left ear
<i>hr gḥ iḥby</i>	upon the left shoulder
<i>fnḏw</i>	the snorting one
<i>ḥntw hr</i>	the lower Khentu
<i>tmyt</i>	sickness
<i>dhrt</i>	bitterness
<i>swnw</i>	physician
<i>rh</i>	healer, wise man
<i>hsb</i>	mathematician
<i>m ʾt</i>	maat, truth, righteousness
<i>nšny</i>	raging one
<i>ḥftt-hr-nb.s</i>	the western side of Thebes
<i>ḥ ʾtyw</i>	slaughterer demons
<i>ḥmi šḥd</i>	back turning star
<i>ḥ</i>	Akh (spirit)
<i>nḥb-k ʾw</i>	Neheb-kau
<i>tḥmw</i>	Tjemehu
<i>nšmt</i>	Neshmet-bark
<i>ḏdft</i>	reptile
<i>ḥrr</i>	pile of corpses
<i>ḥwt-ḏsrt</i>	Deshret temple building

B Frequently asked questions (FAQ)

We have rewritten innumerable versions of this manuscript. The list below contains some of the most frequently asked questions (FAQ) about our research, as well as our short answers. Some of these questions have arisen from misunderstandings of our research. However, we want to answer also those questions, because it was impossible to foresee them coming, or to prepare answers to them beforehand. The sections and the paragraphs (par), where our more detailed answers can be found, are given in parenthesis. These answers are aimed to ensure that our research better stands the test of time and sceptics. The last question 11 is our own. So far, we have not received a reasonable alternative answer to this simple question.

1. Several CC passages mention different deities, but not all of them are included in your analysis. How do you know which one of them determines the calendar date?

Answer: The deities do not determine the dates. The dates are known (Eqs. 1 and 2, Sect. 2.1: 4th and 6th par, Sect. 2.2: 4th last par).

2. Your statistical analysis is flawed, because the exact historical dating of CC is uncertain.

Answer: The results of our statistical analysis do not depend on the zero epoch in time. The time points within CC are unambiguously defined and computed (Eqs. 1 and 2). Hence, the results of our statistical analysis would be the same if CC was dated to ice age, stone age or a million years ahead into the future (Sect. 2.2: 4th last par).

3. Your samples are too small to allow reliable statistical conclusions.

Answer: The ephemerides of Eqs. 5 and 6 are based on large samples of over 500 time points. We use these ephemerides to rearrange the CC passages into the unambiguous order of Lists 1 and 2. These ephemerides work like an accurate modern clock when studying Lists 1 and 2. Furthermore, the binomial significance estimates (Jetsu and Porceddu 2015) Q_B were reliable even for small samples (Sect. 2.2: 3rd last par).

4. Something must be seriously amiss in your method if a term like "Earth" has a strong correlation with Algol's period.

Answer: The ephemeris of Eq. 5 reveals what the authors of CC wrote when they were observing Algol at its different phases. Nothing is "amiss" in our method, unless those CC texts were not written on

Earth (Sect. 2.2: 3rd last par). This is natural because feast dates were often described as feasts in “Earth” and in “Heaven”.

5. Your CC translations are incomplete.

Answer: We have used the hieroglyphic transcription of Leitz (1994) and his original photos of CC, as well the translations of Bakir (1966) (in English) and Leitz (1994) (in German). If some translation modifications could be shown to be necessary, this would not change the general course of events in Lists 1 and 2, or the SW identifications (Sect. 2.2: 2nd last par).

6. You should establish the statistical validity of your analysis by applying a χ^2 -test to your samples.

Answer: Unfortunately, this is not possible for our data samples (Sect. 2.2: last par).

7. A definitive identification of Algol in the Decanal or “star clocks” lists is missing. This weakens your hypotheses.

Answer: It is difficult to identify Egyptian star names in general, but such a definitive identification is not needed, because Algol caused easily observable changes in hour-star patterns or related constellations whether or not it was an actual hour-star (Sect. 4.1: 4th-7th par, Sect. 4.2: 5th par).

8. Most of your presented arguments are speculative, and thus your claims are vague and unproven. Your presented hypotheses are far from being proved.

Answer: This shifts the argumentation from the specific to the general. We make no hypotheses. The previous studies have confirmed the presence of the extremely significant 2.850 days period in CC (Jetsu et al. 2013; Jetsu and Porceddu 2015). Here, we formulate ten specific Arguments I-X in Sects. 4.1- 4.10. It is easy make this type of general and subjective statements about our research without presenting any evidence against even one of our ten arguments.

9. Your manuscript does not report primary research.

Answer: We show that the scribes had the possible means and motives to write the descriptive texts of the regular changes of Algol and the Moon into CC. This must be primary research, unless someone else has solved this question before us.

10. The scope of your research is unsuitable for this journal.

Answer: This journal “disseminates research in both observational and theoretical astronomy, ... as well the surveys dedicated to astronomical history and education.”

11. If the significant 2.850 days period in CC is not connected to Algol, then the following question made by Jetsu and Porceddu (2015) needs to be addressed:

“What was the origin of the phenomenon that occurred every third day, but always 3 hours and 36 minutes earlier than before, and caught the attention of Ancient Egyptians?” In other words, what happened three times in a row at the night-time? Then it occurred during the daytime? After a gap of 13 days, it occurred again during the night-time?

C List 1

$g(14, 2) \equiv \Theta_{\text{Algol}} = 6^\circ$ (Figure 1: “Horus”) “The day of the majesty of Horus receiving the white crown. His Ennead is in a great celebration. Make offering to the gods of your city. Pacify your “akh”[▲].”

$s(5, 8) \equiv \Theta_{\text{Algol}} = 6^\circ$ (Figure 2: “Horus”) “The majesty of Horus is proceeding while Deshret sees his image. Every approach to him is met with rage.”

$g(1, 5) \equiv \Theta_{\text{Algol}} = 13^\circ$ (Figure 1: “Wedjat” and “Sakhmet”)

“Doubled are the offerings, presented the ritual foods. It is the “Neheb-kau”[▲] feast of the gods in front of Ptah, in Ta-tenen in all the temples of the gods and goddesses, in front of Re and his followers. He himself is surrounded by Ptah-Sokar, Sakhmet, Nefertem, Horus-Hekenu and Maahes, the son of Bastet. Light a great fire, pacify the Wedjat. It will be good on this day.”

$g(19, 12) \equiv \Theta_{\text{Algol}} = 13^\circ$ (Figure 1: “Horus”) “Feast for your god! Propitiate your “akh”, because this eye of Horus has come, is complete, is uninjured and there is no claim against it.”

$g(27, 1) \equiv \Theta_{\text{Algol}} = 19^\circ$ (Figure 1: “Horus”) “Peace between Horus and Seth. Do not kill any snakes on this day. Make a good day!”

$g(24, 3) \equiv \Theta_{\text{Algol}} = 19^\circ$ (Figure 1: “Horus”) “The arrival of Isis joyful and Nephthys rejoicing as they see Onnophris’ happiness in giving his throne to his son Horus before Re in heaven.”

$g(1, 7) \equiv \Theta_{\text{Algol}} = 32^\circ$ (Figure 1: “Horus”) “A day of feast of Heaven and of Earth, so too of all people. A feast of entering into heaven. The two banks of Horus rejoice.”

$g(27, 3) \equiv \Theta_{\text{Algol}} = 38^\circ$ (Figure 1: “Horus”) “Judgement between Horus and Seth. Stopping the fight, hunting the rowers, pacifying the raging one. Satisfying of the two lords, causing peace to the land. The whole of Egypt is given to Horus and the whole of desert is given to Seth. Coming forth of Thoth who speaks the decree in front of Re.”

- $g(15, 11) \equiv \Theta_{\text{Algo}} = 38^\circ$ (Figure 1: “Horus”) “If you see a thing, it is good. Horus hears your words in front of every god and every goddess on this day, concerning every good thing you see in your house.”
- $g(1, 9) \equiv \Theta_{\text{Algo}} = 51^\circ$ (Figure 1: “Horus”) “Feast of Horus, the son of Isis. His followers in ...”
- $g(3, 2) \equiv \Theta_{\text{Algo}} = 57^\circ$ (Figure 1: “Wedjat”) “The coming forth of Thoth in the presence of Re in the hidden shrine. He gave the inscription of the pacification of the Wedjat-eye; Hu, Sia and the followers of Maat obey Neith, the crown-goddess in his retinue. If you see anything, it will be good on this day.”
- $g(7, 9) \equiv \Theta_{\text{Algo}} = 88^\circ$ (Figure 1: “Horus”) “The crew and followers of Horus have assembled in the foreign land, to make known that Horus smites him who rebels against his lord. Every land is content, their hearts in great joy.”
- $g(28, 3) \equiv \Theta_{\text{Algo}} = 164^\circ$ (Figure 1: “Horus”) “The gods are in jubilation and in joy over the making of will for Horus, son of Osiris, to pacify Onnophris in the underworld. Then the land is in feast and the hearts of the gods are pleased. If you see anything, it will be good on this day.”
- $g(1, 10) \equiv \Theta_{\text{Algo}} = 240^\circ$ (Figure 1: “Horus”) “Horus... Osiris... Chentechtai... Land”
- $s(26, 1) \equiv \Theta_{\text{Algo}} = 253^\circ$ (Figure 2: “Horus”) “Do not do anything on this day. This is the day of fighting between Horus and Seth. Every man grasped his fellow and they were on their sides as two men. They were turned into two ebonies in the netherworld of the lords of Babylon. Three days and nights were spent in this manner. Then Isis let their harpoons fall. It fell in front of her son Horus. Then he called with a loud voice saying he is her son Horus. Then Isis called to this harpoon: Loosen, loosen from son Horus! Then this harpoon loosened from her son Horus. Then she let fall another harpoon in front of her brother Seth. He shouted saying he is her brother Seth. Then she called to this harpoon: Be strong! Be strong! Then this Seth shouted to her many times saying: Do I love the stranger more than the brother of the mother? Then her heart was greatly saddened and she called to this harpoon: Loosen, loosen! Behold the brother of the mother. So was this harpoon driven from him. They stood up as two men and each turned his back against another. Then the majesty of Horus was angered against his mother Isis like a panther. She placed it in front of him.”
- $s(11, 11) \equiv \Theta_{\text{Algo}} = 253^\circ$ (Figure 2: “Horus”) “Re’s bringing of the great ones to the booth to see what he had seen through the eye of Horus the Elder. Then their faces were turned down seeing the eye of Horus raging in front of Re. Do not perform any ritual in any house on this day.”
- $s(10, 6) \equiv \Theta_{\text{Algo}} = 259^\circ$ (Figure 2: “Wedjat”) “The coming forth of Wedjat into the presence of the favoured ones in Heliopolis. The promotion of the Majesty of the shrines through Mnevis-bull, the herald of Re, whom Maat raised up to Atum.”
- $s(27, 8) \equiv \Theta_{\text{Algo}} = 265^\circ$ (Figure 2: “Sakhmet”) “Do not go out of your house until the setting of the sun because the majesty of Sakhmet violates in “Tjemehu”[▲], where she is walking without anyone nearby.”
- $g(16, 4) \equiv \Theta_{\text{Algo}} = 278^\circ$ (Figure 1: “Sakhmet”) “This is the day of the feast of Sakhmet and Bastet in Asheru for Re, given in front of Re.”
- $s(13, 6) \equiv \Theta_{\text{Algo}} = 278^\circ$ (Figure 2: “Sakhmet”) “Do not go out of your house to any road on this day. This is the day of the arrival of Sakhmet of Reheset. Their great “slaughterer-demons” were let loose from Letopolis on this day.”
- $s(7, 10) \equiv \Theta_{\text{Algo}} = 278^\circ$ (Figure 2: “Sakhmet”) “Do not go out of your house to spend time until the setting of the sun to the horizon. This is the day of the hidden-named “slaughterer-demons” of Sakhmet...”
- $g(23, 7) \equiv \Theta_{\text{Algo}} = 291^\circ$ (Figure 1: “Horus”) “Feast of Horus in Athribis on this day of his years, in his great and beautiful images.”
- $g(29, 3) \equiv \Theta_{\text{Algo}} = 291^\circ$ (Figure 1: “Horus”) “Coming forth of the three ancestors inside the Tanenet in front of Ptah, beautiful of face, while adoring Re of the throne of the truth of the goddess temples. The white crown is given to Horus and the red one to Seth. Their hearts are pleased upon them.”
- $s(20, 9) \equiv \Theta_{\text{Algo}} = 291^\circ$ (Figure 2: “Horus”) “The judgement of Maat in front of these gods, angered on the island of the sanctuary of Letopolis, inspected by the majesty of Horus.”
- $g(9, 5) \equiv \Theta_{\text{Algo}} = 303^\circ$ (Figure 1: “Sakhmet”) “The gods are joyful over the matter of Sakhmet. The day of establishing the food offerings and reversion-offering, which are pleasing to the gods and the “akh”.”
- $g(30, 10) \equiv \Theta_{\text{Algo}} = 303^\circ$ (Figure 1: “Wedjat”) “The coming forth of Shu to bring back Wedjat, pacified by

Thoth on this day. House of Re. House of Osiris. House of Horus."

- $g(29, 5) \equiv \Theta_{\text{Algol}} = 309^\circ$ (Figure 1: "Sakhmet") *"Appearance in glory in the sight of Hu by Thoth to send this decree southwards to instruct the two lands of Bastet together with the sole mistress Sakhmet the great. The gods are pleased. If you see anything, it will be good on this day."*
- $g(18, 1) \equiv \Theta_{\text{Algol}} = 322^\circ$ (Figure 1: "Horus") *"If you see anything, it will be good on this day. This is the day of magnifying the majesty of Horus over his brother, which they did at the gate."*
- $g(6, 9) \equiv \Theta_{\text{Algol}} = 322^\circ$ (Figure 1: "Wedjat") *"The coming of the great ones from the House of Re. Joy on this day, as they catch Wedjat together with their followers. If you see anything, it will be good on this day."*

D List 2

- $g(1, 9) \equiv \Theta_{\text{Moon}} = 0^\circ$ (Figure 3: "Horus") *"Feast of Horus, the son of Isis. His followers in ..."*
- $g(1, 10) \equiv \Theta_{\text{Moon}} = 5^\circ$ (Figure 3: "Horus" and "Osiris") *"Horus... Osiris... Chentechtai... Land"*
- $s(5, 8) \equiv \Theta_{\text{Moon}} = 44^\circ$ (Figure 4: "Horus") *"The majesty of Horus is proceeding while Deshret sees his image. Every approach to him is met with rage."*
- $g(6, 7) \equiv \Theta_{\text{Moon}} = 51^\circ$ (Figure 3: "Osiris") *"Joy of Osiris at the tomb of Busiris. The coming forth of Anubis, adoration in his wake, likewise he has received all people. (his) adorers (or, adoration) following him; he has received everybody in the hall. Perform a ritual!"*
- $g(9, 4) \equiv \Theta_{\text{Moon}} = 73^\circ$ (Figure 3: "Seth") *"It is the day of doing what Thoth did. 'The djed-pillars endure', says Re in front of the great ones, whereupon these gods together with Thoth let the enemy of Seth kill himself in front of his sanctuary. This is what was done by the 'slaughterer-demons' of Qesret on this day."*
- $g(7, 9) \equiv \Theta_{\text{Moon}} = 73^\circ$ (Figure 3: "Horus") *"The crew and followers of Horus have assembled in the foreign land, to make known that Horus smites him who rebels against his lord. Every land is content, their hearts in great joy."*
- $g(11, 4) \equiv \Theta_{\text{Moon}} = 98^\circ$ (Figure 3: "Osiris") *"Feast of Osiris in Abydos in the great 'neshmet-bark'▲ on this day. The dead are in jubilation."*
- $s(12, 2) \equiv \Theta_{\text{Moon}} = 100^\circ$ (Figure 4: "Seth") *"This is the day of raising his head by the one who rebelled against his lord. His intent is destroyed and the staff of Seth, son of Nut. His head, who did rebel against his lord, is cut off."*
- $s(13, 3) \equiv \Theta_{\text{Moon}} = 117^\circ$ (Figure 4: "Seth" and "Osiris") *"This is the day of severing... the ferryman upon the uncrossable river of snakes... every hall to this 'neshmet-bark' of Osiris, sailing southwards to Abydos, to the great city of Onnophris. For he has made his form into one old and small in the arms of (translation unknown)... given gold as reward to Nemti for fare, saying 'Ferry us to the west!' Then he received it... upon a limb of the divine body, whereupon was this association behind him as an army of 'reptiles'▲. Then they knew Seth had made these gods enter to purify the limb of the divine body. Then they revived it... he came... the enemy behind him on the water. Then they changed their forms into little, small cattle. Then these gods made a 'pile of corpses'▲ and split them entirely. Then was taken action upon the tongue of the enemy of Nemti. Do not approach the gold in the house of Nemti as far as this day. So began the removal of the little, small cattle from the west, so began the creation of the herds of little, small cattle as far as this day. "*
- $g(14, 2) \equiv \Theta_{\text{Moon}} = 124^\circ$ (Figure 3: "Horus") *"The day of the majesty of Horus receiving the white crown. His Ennead is in a great celebration. Make offering to the gods of your city. Pacify your akh."*
- $s(14, 3) \equiv \Theta_{\text{Moon}} = 129^\circ$ (Figure 4: "Osiris") *"Do not do anything on this day. The hearts of the gods are sad over the action against Osiris' place of embalming and the action of the enemy of Nemti. All born on this day will die of cuts."*
- $s(11, 11) \equiv \Theta_{\text{Moon}} = 132^\circ$ (Figure 4: "Horus") *"Re's bringing of the great ones to the booth to see what he had seen through the eye of Horus the Elder. Then their faces were turned down seeing the eye of Horus raging in front of Re. Do not perform any ritual in any house on this day."*
- $s(11, 12) \equiv \Theta_{\text{Moon}} = 137^\circ$ (Figure 4: "Seth") *"The causers of tumult are in front of the followers of Re, who repelled the confederacy of Seth to the eastern desert."*
- $s(14, 5) \equiv \Theta_{\text{Moon}} = 139^\circ$ (Figure 4: "Osiris") *"Weeping of Isis and Nephthys. It is the day of their mourning Osiris in Busiris in remembrance of that which*

- he had seen. Do not listen to singing or music on this day.*"
- $g(16, 2) \equiv \Theta_{\text{Moon}} = 149^\circ$ (Figure 3: "Osiris") "Feast of Osiris-Onnophris. The gods who are in his attendance are in great celebration. The Ennead is before Re, joyful. If you see anything on this day, it will be good."
- $g(13, 12) \equiv \Theta_{\text{Moon}} = 161^\circ$ (Figure 3: "Seth" and "Osiris") "A holiday because of protecting the son of Osiris. . . at the back of the portal by Seth."
- $g(18, 1) \equiv \Theta_{\text{Moon}} = 168^\circ$ (Figure 3: "Horus") "If you see anything, it will be good on this day. This is the day of magnifying the majesty of Horus over his brother, which they did at the gate."
- $s(18, 3) \equiv \Theta_{\text{Moon}} = 178^\circ$ (Figure 4: "Seth") "This is the day of tumult by the children of Geb: Seth and his sister Nephthys. Do not approach any road until the deed is done on this day."
- $g(15, 11) \equiv \Theta_{\text{Moon}} = 180^\circ$ (Figure 3: "Horus") "If you see a thing, it is good. Horus hears your words in front of every god and every goddess on this day, concerning every good thing you see in your house."
- $g(17, 6) \equiv \Theta_{\text{Moon}} = 180^\circ$ (Figure 3: "Osiris") "This is the day of bringing to the embalming place of Osiris those offerings which have been placed in the hands of Anubis."
- $s(17, 7) \equiv \Theta_{\text{Moon}} = 185^\circ$ (Figure 4: "Seth") "Do not speak the name of Seth on this day. Who in his lack of knowledge pronounces his name, he will not stop fighting in his house of eternity."
- $s(17, 8) \equiv \Theta_{\text{Moon}} = 190^\circ$ (Figure 4: "Seth") "The going of Seth, son of Nut, to the brawlers that have been reckoned on his day. These gods became aware of him, they repelled his followers and none of them remained."
- $s(19, 4) \equiv \Theta_{\text{Moon}} = 195^\circ$ (Figure 4: "Osiris") "Stealing of property inside the Deshret "temple building"[▲]. Making of ointment for Osiris in front of the funerary workshop. Do not taste bread or beer on this day. Drink the juice of grapes until Re sets."
- $s(20, 2) \equiv \Theta_{\text{Moon}} = 197^\circ$ (Figure 4: "Seth") "This is the day of giving food-offerings in front of Re and followers by Thoth. The act in there was done accordingly. The rebels against their lord were overthrown. Then they lifted up Seth, son of Nut; so they became lowered by the gods."
- $s(20, 9) \equiv \Theta_{\text{Moon}} = 231^\circ$ (Figure 4: "Horus") "The judgement of Maat in front of these gods, angered on the island of the sanctuary of Letopolis, inspected by the majesty of Horus."
- $g(19, 12) \equiv \Theta_{\text{Moon}} = 234^\circ$ (Figure 3: "Horus") "Feast for your god! Propitiate your "akh", because this eye of Horus has come, is complete, is uninjured and there is no claim against it."
- $g(24, 3) \equiv \Theta_{\text{Moon}} = 251^\circ$ (Figure 3: "Horus") "The arrival of Isis joyful and Nephthys rejoicing as they see Onnophris' happiness in giving his throne to his son Horus before Re in heaven."
- $g(23, 7) \equiv \Theta_{\text{Moon}} = 258^\circ$ (Figure 3: "Horus") "Feast of Horus in Athribis on this day of his years, in his great and beautiful images."
- $s(26, 1) \equiv \Theta_{\text{Moon}} = 266^\circ$ (Figure 4: "Horus" and "Seth") "Do not do anything on this day. This is the day of fighting between Horus and Seth. Every man grasped his fellow and they were on their sides as two men. They were turned into two ebonies in the netherworld of the lords of Babylon. Three days and nights were spent in this manner. Then Isis let their harpoons fall. It fell in front of her son Horus. Then he called with a loud voice saying he is her son Horus. Then Isis called to this harpoon: Loosen, loosen from son Horus! Then this harpoon loosened from her son Horus. Then she let fall another harpoon in front of her brother Seth. He shouted saying he is her brother Seth. Then she called to this harpoon: Be strong! Be strong! Then this Seth shouted to her many times saying: Do I love the stranger more than the brother of the mother? Then her heart was greatly saddened and she called to this harpoon: Loosen, loosen! Behold the brother of the mother. So was this harpoon driven from him. They stood up as two men and each turned his back against another. Then the majesty of Horus was angered against his mother Isis like a panther. She placed it in front of him."
- $s(24, 8) \equiv \Theta_{\text{Moon}} = 275^\circ$ (Figure 4: "Seth") "Do not pronounce the name of Seth. Do not raise your voice on this day. This is the day of Onnophris. As to anyone who pronounces his name in ignorance, he shall not cease fighting in his house for ever."
- $g(27, 1) \equiv \Theta_{\text{Moon}} = 278^\circ$ (Figure 3: "Horus" and "Seth") "Peace between Horus and Seth. Do not kill any snakes on this day. Make a good day!"
- $g(27, 3) \equiv \Theta_{\text{Moon}} = 287^\circ$ (Figure 3: "Horus" and "Seth") "Judgement between Horus and Seth. Stopping the fight, hunting the rowers, pacifying the raging one. Satisfying of the two lords, causing peace to the land. The whole of Egypt is given to Horus and the whole of desert is given to Seth."

Coming forth of Thoth who speaks the decree in front of Re.”

$g(28, 3) \equiv \Theta_{\text{Moon}} = 300^\circ$ (Figure 3: “Horus” and “Osiris”) *“The gods are in jubilation and in joy over the making of will for Horus, son of Osiris, to pacify Onnophris in the underworld. Then the land is in feast and the hearts of the gods are pleased. If you see anything, it will be good on this day.”*

$g(29, 3) \equiv \Theta_{\text{Moon}} = 312^\circ$ (Figure 3: “Horus” and “Seth”) *“Coming forth of the three ancestors inside the Tanenet in front of Ptah, beautiful of face, while adoring Re of the throne of truth of the goddess temples. The white crown is given to Horus and the red one to Seth. Their hearts are pleased upon them.”*

$g(28, 7) \equiv \Theta_{\text{Moon}} = 319^\circ$ (Figure 3: “Osiris”) *“Feast of Osiris in Abydos. The majesty of Onnophris raised up the willow.”*

$g(1, 7) \equiv \Theta_{\text{Moon}} = 351^\circ$ (Figure 3: “Horus”) *“A day of feast of Heaven and of Earth, so too of all people. A feast of entering into heaven. The two banks of Horus rejoice.”*