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Representations of calendars and time at Göbekli Tepe and Karahan Tepe support an astronomical interpretation of their symbolism

Martin B. Sweatman

Institute of Materials and Processes, School of Engineering, University of Edinburgh, King's Buildings, Edinburgh, Scotland, UK. EH9 3JL.

email: martin.sweatman@ed.ac.uk

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ABSTRACT

Göbekli Tepe, an archaeological site in southern Turkey, features several temple-like enclosures adorned with many intricately carved symbols. It is located centrally among a group of pre-pottery Neolithic sites which include Karahan Tepe and Sayburç. Here, an earlier astronomical interpretation for Gobekli Tepe's symbolism is supported and extended by showing how V-symbols on Pillar 43 in enclosure D can be interpreted in terms of a lunisolar calendar system with 11 epagomenal days, which would make it the oldest known example of its type. Furthermore, it is shown how Göbekli Tepe's 11-pillar enclosures and a megalithic 11-pillar pool structure at nearby Karahan Tepe can also be interpreted in terms of the same lunisolar calendar system. Other V-symbols at Göbekli Tepe are also
1. Introduction

Humans have been carefully observing the stars for over 50,000 years. Indeed, widespread myths involving the Pleiades are often so similar, typically involving stories of six or seven sisters or birds, it is suggested they have a common origin in the middle Palaeolithic (d'Huy and Berezkin (2017); Norris and Norris (2021)). It should be no surprise that astronomy was seen as important at such an early time. Until relatively recently, life depended on paying close attention to the seasons since all resources depended on them, at higher latitudes at least. Since the seasons can be tracked easily by observing the solstices and equinoxes, we can expect many ancient cultures to have a significant interest in astronomy. It follows that they would also take a keen interest in the lunar cycle.

In more recent times, many Bronze and Iron Age cultures were known, or strongly suspected, to encode astronomical data in their megalithic monuments (Krupp, 1983). For example, one of the most famous ancient megalithic sites of all, Stonehenge (UK, circa 2,500 BCE), is thought to be arranged to celebrate either the summer or winter solstice or both (Hawkins, 1963; Parker-Pearson, 2013). Recent work suggests it also encodes a solar calendar (Darvill, 2022). Meanwhile, many recumbent stone circles in North-East Scotland of a similar age to Stonehenge that typically feature 11 or 12 megaliths are suggested to relate to the lunar cycle (Henty, 2014). An ancient temple in Malta, on the other hand, appears to be deliberately aligned with sunrise on the equinoxes (Cox and Lomsdalen, 2010). Indeed, ancient temples and pyramids across the world are aligned so closely to the cardinal directions, it is clear that careful astronomical observations were being made routinely in early antiquity. Moreover, it is well-known that many ancient cultures, including those from Egypt and Mesopotamia, practised religions with strong astronomical associations (North, 2008; Krupp, 2000). This includes conceptions of deities linked with constellations and zodiac-like animal symbols or with the planets (Kurtik, 2019; Kurtik, 1999).

It is in this context that archaeoastronomy has become a popular way of understanding
is Göbekli Tepe. Situated in modern southern Turkey, it became famous for its extraordinary megalithic architecture consisting of multiple stone 'enclosures' (Schmidt, 2000; Schmidt, 2010; Schmidt, 2011; Dietrich et al., 2011). Each enclosure (see Figure 1a) consists of a sub-circular rough stone wall embedded with megalithic T-shaped pillars, many of which are adorned with a rich symbolism. It is worth noting that enclosure D and the inner ring of enclosure C are both studded by 11 T-shaped pillars. Each enclosure also contains a central pair of tall pillars consistent with a world-wide ‘twin’ sky-deity mythology (Coombs, 2023).

Figure 1. a) Plan of enclosures A to D at Göbekli Tepe. b) Pillar 43 at Göbekli Tepe, enclosure D (image courtesy of Alistair Coombs).

Earlier work provided an astronomical interpretation for some of Göbekli Tepe’s symbolism.
Furthermore, Pillars 2 and 38 at Göbekli Tepe were suggested to describe the path of the radiant of the Taurid meteor stream which is thought to have caused this impact event. And Pillar 18, one of the two central pillars from enclosure D, was suggested to symbolise a comet related to the impact event.

If this interpretation is correct, it has profound consequences. Partly, this is because it implies that astronomical knowledge was far in advance of what is generally assumed for this time. Another reason is because of Göbekli Tepe's position in relation to the Palaeolithic-Neolithic transition in the Fertile crescent. Indeed, according to the site's excavators (Dietrich et al., 2012),

"Göbekli Tepe is one of the most important archaeological discoveries of modern times, pushing back the origins of monumentality beyond the emergence of agriculture. ... At the dawn of the Neolithic, hunter-gatherers congregating at Göbekli Tepe created social and ideological cohesion through the carving of decorated pillars, dancing, feasting—and, almost certainly, the drinking of beer made from fermented wild crops."

In essence, their view is that Göbekli Tepe, for which the earliest date yet recorded is 9,530 ± 215 BCE (Dietrich et al., 2013), played an important role in the Neolithic revolution that followed by creating the social conditions for large, settled communities to develop prior to the development of agriculture. This aligns well with Cauvin's theory for the origin of civilisation in the Fertile Crescent, as he suggested it was triggered by a change in cognition related to religion and symbolism. With these views, the prime importance of agriculture in initiating this process is diminished. Therefore, if it was confirmed that Göbekli Tepe's impressive symbolism and architecture were related to the Younger Dryas impact event, it would suggest this cosmic event also played a pivotal role in the origin of civilisation in the Fertile Crescent (Sweatman, 2017 and 2019). That is, the dramatic growth of religion and symbolism after the onset of the Younger Dryas central to Cauvin's thesis might have been triggered by the Younger Dryas impact.

Over the last decade, several other pre-pottery Neolithic sites near Göbekli Tepe have been discovered, including Karahan Tepe, which suggest that Göbekli Tepe existed as part of an extended local culture. Due to similarities in their geographical location, symbolism and age these sites have been grouped under the Taş Tepeler archaeological project. Consequently, observations about the importance of Göbekli Tepe in relation to cultural changes after the Younger Dryas impact might also apply to these sites, although a detailed relative
2. Background

The main purpose of this paper is to provide an interpretation for the V-symbols found on Göbekli Tepe's pillars and at other locations at Taş Tepeler sites, and to explain how this supports an earlier astronomical interpretation for Göbekli Tepe's symbolism. As already mentioned, this astronomical interpretation could have significant implications for our understanding of the Neolithic revolution in the Fertile Crescent. However, before any of these topics can be explored, a great deal of background information must be discussed. Therefore, this paper is organised as follows.

First, in section 2.1 the Taş Tepeler sites of southern Turkey, including Göbekli Tepe, Karahan Tepe, ancient Urfa and Sayburç, are introduced and their importance to the Neolithic revolution is described. The most important pillars and symbols at Göbekli Tepe are then described in detail. Earlier research on the symbolism at these and related sites from a wider region is then reviewed. Much of this earlier research typically eschews an astronomical interpretation despite some clear signals that this approach is likely to be fruitful and despite the breakthrough provided by Sweatman and Tsikritsis (2017a).

Given these clear indications that the symbolism at Göbekli Tepe could be largely astronomical in nature, the rest of the paper examines evidence that supports an astronomical interpretation of V-symbols at Göbekli Tepe and other Taş Tepeler sites. This examination begins in section 2.2 with evidence for a widespread system of Upper Palaeolithic astronomy, focussing on symbolism associated with possible lunar calendar systems and solstitial/equinoctial observations. The possibility of observational knowledge of precession at this time is also discussed, along with Gurshtein's (2005) proposal of an early system of zodiacal dating based on precession. This provides the context for the remaining discussion since it suggests the level of astronomical knowledge proposed at Göbekli Tepe by Sweatman and Tsikritsis (2017a) was already known for thousands of years.

This is followed by a discussion of the (unknown) origin of the Greek constellations in
We now have sufficient background and context to discuss Sweatman and Tsikritsis' (2017a) astronomical interpretation of Göbekli Tepe, which is summarized next in section 2.6. Especially, it is shown how Pillar 43 at Göbekli Tepe can be viewed as strong evidence supporting Gurshtein's prediction for a Neolithic system of zodiacal dating, although it appears at a much earlier date than he envisaged and is more sophisticated.

After this lengthy introduction, the main findings of this work are described in section 3. This involves in section 3.1 a survey of V-symbols found within the Taş Tepeler region followed by an interpretation of their meaning including the encoding of a lunisolar calendar on Pillar 43 at Göbekli Tepe. It is shown how this discovery supports the astronomical interpretation of Sweatman and Tsikritsis (2017a) which is central to this work. This then leads to calendrical interpretations for some of the megalithic structures at Göbekli Tepe and Karahan Tepe in section 3.2 and to an astronomical interpretation of the Urfa Man statue, a statue at Karahan Tepe and a Sayburç wall carving in section 3.3. Symbolic connections are then made with several later cultures from the eastern Mediterranean, notably ancient Egypt and Mesopotamia, in section 4.1.

Finally, the relevance of the astronomical interpretation of Göbekli Tepe's symbolism to Cauvin's (2000) theory for the origin of the Neolithic revolution is discussed in section 4.2. This work is concluded by discussing the merits and consequences of this astronomical interpretation in section 5.

2.1 Göbekli Tepe and the Taş Tepeler region in the context of the Neolithic revolution

The Neolithic revolution in the Fertile Crescent, a.k.a. the 'broad spectrum' transition, exhibits a complex pattern of development over many millennia. It is typically characterised in terms of changes in several key markers, such as settlement density and population, architecture, agriculture, lithics and art (Cauvin, 2000; Watkins, 2010). A few decades ago, most attention was focussed on archaeological sites in the Levant and lower Mesopotamia as these showed signals of all these developments earlier than anywhere else in the world. The overall result of all this work was that a few signals of this transition could be observed before the Younger Dryas period (i.e. before 11,000 BCE) but a phase of rapid development took place after the Younger Dryas onset, i.e. within the Younger Dryas period and especially within the Holocene once climate had stabilised.
houses with semi subterranean walls built from large stone blocks, such as those found at Tell Qaramel (Mazurowski et al., 2009). Although it is thought they cultivated some wild grains, they nevertheless remained hunter-gatherers. Settlement populations remained quite small at no more than a few hundred.

However, after the Younger Dryas period, within a span of a few thousand years, we see the rapid development of domesticated plants and animals, a larger number of settlements with higher populations, rectangular houses built entirely above ground from mud-brick and specialised buildings used for cultic purposes, more specialised use of stone tools and the emergence of a richer form of symbolic art (Watkins, 2010).

Since it was often thought that these changes were all driven by developments in agriculture at the beginning of the Holocene period (Bar-Yosef, 1998), the hunt for the origin of this Neolithic revolution tracked the earliest domestication of plants and animals to northern (upper) Mesopotamia close to the foothills of the Taurus Mountains (Watkins, 2010). Well-known pre-pottery sites, such as Çayönü, Nevali Çori, Hallan Çemi, Abu Hureyra and Jerf al Amar in this region (see Figure 2a) also display other features of this Neolithic transition at a very early time. However, in this region we see a rapid development in symbolic art millennia before clear indications of domesticated species of plant or animal. This led Cauvin (2000) to propose that this cultural transition was triggered by cognitive changes, especially the development of religion and associated symbolic artworks. In his view, agriculture developed later in response to the growth of settlements around cultic centres.

Following this interest in upper Mesopotamia, Göbekli Tepe was discovered towards the end of the last century in the hills overlooking the Harran Plain (see Figure 2a). It is situated between the upper reaches of the Euphrates and Tigris rivers, around 12 kms north-east of the modern city of Şanliurfa, which was ancient Urfa and said to the birthplace of Biblical Abraham.
Excavations of the tell (mound) at Göbekli Tepe began in 1994 (Schmidt, 2000). They revealed four large sub-circular enclosures (labelled A to D, see Figure 1a) and many other
A settlement with the rectangular buildings thought now to be houses (Clare, 2020). While the large enclosures are still considered 'special' buildings, it is debated whether they had a specific cultic purpose or whether they were the larger homes of important families (Kinzel and Clare, 2020). In the context of this debate, it is argued whether the largest pillars could represent deities or perhaps revered ancestors. In either case, it is generally thought these large enclosures were roofed, although firm evidence is elusive.

The largest complete enclosure so far uncovered, enclosure D at 30 m across, generated the oldest radiocarbon date yet measured for the site at 9,530 ± 215 BCE (Dietrich et al., 2013). This date corresponds approximately to the end of the Younger Dryas period at the Epipaleolithic-Neolithic boundary when northern-hemisphere climate rocketed upwards after over 1,200 years of near ice-age Younger Dryas climate. However, the earliest occupation date of Göbekli Tepe is unknown. Ground-penetrating radar scans suggest several other large structures situated towards the centre of the main tell also exist, waiting to be uncovered. In fact, given that less than ~ 10% of the site's surface (which covers around 7 hectares) has been excavated, with an even smaller area excavated down to bedrock, it is possible that Göbekli Tepe's origin will eventually be found to date closer to the onset of the Younger Dryas around 10,800 BCE. Indeed, Schmidt (2010) suggested it could have a Palaeolithic origin, and in a recent report Kinzel and Clare (2020) state that a Younger Dryas origin cannot be ruled out.

In fact, the scale and precision of enclosure D clearly indicate that it was unlikely the first construction of its type. We can expect at least one, and possibly several, earlier stages of design and construction preceded it by many hundreds of years, although it is not known if these occurred at Göbekli Tepe itself. Indeed, a fifth sub-circular feature at Göbekli Tepe called enclosure E situated just outside the main tell might represent an earlier phase of construction. This view is supported by the fact that its pillars and walls are missing and thus might have been removed and re-used within the other enclosures. Only its smoothed bedrock floor, which appears smaller and more primitive than enclosure D's, remains, complete with a pair of centrally-located stone sockets presumably designed to hold another central pair of tall pillars.

Over the last few decades, several more ancient archaeological sites with some similar features have been discovered in the local region surrounding Göbekli Tepe. They include Karahan Tepe, Sayburç and Balıklıgöl Höyük (within ancient Urfa), where the Urfa Man statue was found. Given their proximity to each other and their apparently similar
Göbekli Tepe's architecture and symbolism are extraordinary for its age. No other site constructed before it, or for millennia after, is known to display such a grand architectural vision and such skilful artistry. However, elements of its design are seen elsewhere within the Taş Tepeler region, and beyond, which suggests Göbekli Tepe played an important role in establishing a settled culture in the pre-pottery Neolithic era of this region. For example, Nevali Çori has rectangular communal buildings with T-shaped pillars. Most notably, Karahan Tepe in the east of the Taş Tepeler region about 40 kms from Göbekli Tepe shows most similarities with Göbekli Tepe in that it also features large sub-circular enclosures with T-shaped pillars and zoomorphic carvings. It is also known to be a large site, perhaps even larger than Göbekli Tepe (Karul, 2020). Nevertheless, even Karahan Tepe does not yet display the same level of grandeur or artistry as Göbekli Tepe, although excavations there began only in the last few years. It is worth noting that no evidence for domesticated species of plant or animal has yet been found at Göbekli Tepe or Karahan Tepe.

Clearly, to understand the sequence of events that lead to Göbekli Tepe’s construction, which will likely hold clues to the motivation for the cultural transition at the onset of the Neolithic period in this region, it will be important to decode the rich symbolism covering many of its pillars.

To this end, consider first Pillar 18, one of the tall pair of pillars at the centre of enclosure D with an anthropomorphic form consisting of a horizontal ‘head’ on top of a vertical ‘body’. The ‘necklace’ symbol underneath the head of Pillar 18 (see Figure 3a) can intuitively be interpreted as a moon and sun symbol below an abstract H-symbol. The disc and H-symbols are obscured by dimples.

The Sun and Moon were viewed as deities by many ancient cultures, including several from the Near East. Consequently, solar disks and lunar crescents are common cultic and religious symbols. Indeed, the ancient Egyptians used these symbols specifically to denote the Sun and Moon in their hieroglyphic writing. Moreover, the symbols found on Pillar 18 bear strong resemblance to those found on the Nebra sky-disk, an artifact discovered in modern Germany thought to date to the 2nd millennium BCE (see Figure 3d and Goral, 2020). On the sky-disc we see the Moon, Sun and, probably, the Pleiades. The two opposing arcs along the edges of the disk are thought to measure the angle between the rising and setting points of the sun on the summer and winter solstices. The identity of the final feature at the bottom of the disk, the long, curved shape incised with parallel lines, is contentious, but one possibility is that it is a comet.
Additionally, on the front of the pillar below a pair of hands is a geometric belt buckle and fox-pelt loin cloth that can be viewed as representing the head and tail of a comet respectively (see Figure 3c). Thus, it appears that the Nebra sky-disk and the narrow face of Pillar 18 appear to display very similar information.

Given the Nebra sky-disk is generally thought to depict astronomical data, its similarity to the front face of one of the largest pillars within a special structure at Göbekli Tepe suggests we should immediately consider the possibility that much of the symbolism at Göbekli Tepe is astronomical.
The H-symbol is relatively common at Göbekli Tepe, although until now the example near the head of Pillar 18 is the only one carrying a dimple, which suggests the dimple has a special astronomical meaning. However, the circular disk symbol, likely representing the sun, is currently relatively rare. The only other example uncovered so far at Göbekli Tepe is on Pillar 43, which is embedded in the north-west portion of enclosure D’s wall (see Figure 1b).

Figure 4. Left: a scene around Scorpius from Stellarium. The teapot asterism of the Sagittarius constellation is drawn in yellow. Right: a sketch of Pillar 43.
4. The lower, main portion has a circular disk symbol supported above the wing of a vulture or eagle. Below this bird symbol is a scorpion symbol. If the circular disk represents the sun, as expected, then the animal symbols probably represent constellations. In particular, the scorpion reminds us of the Greek Scorpius constellation. Its position relative to a circular disk clearly points to an astronomical interpretation.

Despite these rather obvious astronomical clues, other than in the work of Sweatman and Tsikritsis (2017a) interpretation of these symbols is generally quite cautious and vague. Peters and Schmidt (2004) favoured the possibility the symbols indicated shamanistic practices and especially a ‘cult of the deceased’, i.e. that ancestor worship was important. Although they found some correspondence between the animals depicted on the pillars and animal remains excavated from the enclosures, they viewed the animals depicted as mythological creatures rather than direct representations of wild animals and food sources. Essentially, Göbekli Tepe’s enclosures were viewed as temple-like constructions for the performance of rituals, and the animal symbols were thought likely to be totems associated with shamanism.

Hodder and Meskell (2011) compared the symbolism found at Göbekli Tepe with that at Çatalhöyük. They found that although Çatalhöyük is around 450 km to the east of Göbekli Tepe and separated from it by around one millennium, a clear similarity is the focus on wild rather domestic animals, even though Çatalhöyük is agricultural. They note some continuity in terms of animal species between the two sites, like the aurochs, but there are also some clear differences, i.e. foxes, snakes, spiders and scorpions are much more common at Göbekli Tepe. They also highlight the concept of ‘history houses’ developed at Çatalhöyük and associated with human burials interred with animal parts, and a possible skull cult associated with de-fleshing by raptors. Regarding the latter, they point out that images of headless men and vultures are common to both sites. Especially, they suggest the circular disk above the eagle/vulture’s wing on Pillar 43 (see Figure 4) could symbolise a decapitated head.

However, human burials appear to be mostly absent at Göbekli Tepe, and given the artistic talent displayed on Pillar 43 it is evident that if the circular disk was meant to symbolise a decapitated head it would probably have been carved to look a lot more like a head than a featureless disk. Nevertheless, they conclude,

“The similarities between Çatalhöyük and Göbekli and in material culture we have drawn with other sites suggest that we are watching the same phenomena operating in some continuity in human affairs.”

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Regarding the similarities in material culture with other sites, burials of humans with the remains of specific species of animals, such as fox and aurochs, are documented at several pre-pottery Neolithic (PPN) sites in the Levant (Horwitz and Goring-Morris, 2004; Maher et al., 2011; Reshef et al., 2019). Such practices are often linked with shamanism (Kolankaya-Bostanci, 2014; Dietrich, 2023). In addition, images of snakes, scorpions and ibex are documented at Kortiktepe on stoneware and bone plaques (Siddiq et al., 2021). Note that the oldest layers of Kortiktepe date to just after the Younger Dryas onset. Images of snakes or serpents are common across a wide range of PPN Neolithic sites (Çelik, 2016).

While some later work takes a utilitarian view of the animal symbols as representing predators and/or food sources (Fagan, 2017), largely ignoring the obvious astronomical symbols present at Göbekli Tepe, a more frequent direction for research into the site's symbolism has tended to focus on emphasizing the role of shamanistic practices, in line with Schmidt's initial views. In the most recent contribution of this kind, Dietrich (2023) concludes,

"The present contribution has tried to refine already established criteria for the identification of shamanism, to add new ones, and to test them for materials from Göbekli Tepe and contemporary sites. The results are positive for a sufficient number of criteria (Table 1) in order to identify Göbekli Tepe's (and PPN) material culture and imagery with an animistic ontology and shamanism."

Nevertheless, Dietrich (2023) and others avoid any astronomical interpretation of Göbekli Tepe's symbolism, other than acknowledging that the disk on Pillar 43 could represent the sun. Instead, the animals and other symbols are sometimes viewed mythologically and at other times as real-world creatures and objects.

Another recent direction in research has been to introduce psychological theory into interpretation of Göbekli Tepe's symbolism (Henley, 2018). For example, Hayden (2019) concurs with the shamanistic paradigm, and focuses on the role of the shaman in a developing settlement.
research supportive of the Younger Dryas impact are cited in the above research, despite the strong evidence in their favour and the clear possibility that the Younger Dryas impact motivated the rapid development in symbolism and cultic practices following the impact event, i.e. it is an explanation for Cauvin's (2000) observations.

Given this general hesitance to view Göbekli Tepe's symbolism astronomically, the remainder of this paper describes evidence that supports an astronomical viewpoint. This examination begins in the next section by reviewing the evidence for astronomy in the preceding Palaeolithic period.

2.2 European Upper Palaeolithic astronomy and Gurshtein's prediction

Any Palaeolithic hunter-gather tribe wishing to improve their lot would do well to study the motion of the sun and moon. Although weather varies dramatically on a daily basis, the seasons change slowly and predictably in time with the annual solar cycle. Since all resources are seasonal, at least far away from the equator, family and tribal life can be planned and optimised by studying the sun's motion. Most easily, this is achieved by noting its rise and setting points on the horizon.

Any astute observer will soon recognise several interesting aspects of this motion. First, the limits of this motion define special days in the year; the solstices and equinoxes. These days will then likely take on important communal functions, such as social gatherings, and we can expect to encounter symbolism connected with them. Through noting these points on the horizon, true north can be defined. It will then be noticed this direction correlates exactly with a stationary point in the night sky, which can be associated with a pole star. These connections indicate there is a deeper understanding of nature to be gained from astronomy and they highlight the importance of the solstices and equinoxes.

A keen observer will also notice the regular motion of the stars at night, and how the sun and moon's rise and setting positions on the horizon can be recorded using the brightest stars. In turn, this will lead inevitably to the definition of constellations.

Any observant tribe that records the rise and setting point of the sun on the solstices and equinoxes against the constellations for several generations will notice a strange effect; the heavens appear to be shifting slowly. This is precession of the equinoxes. This motion is equivalent to a shift of about two moon-widths in a person's lifetime (~ 70 years) and is
Prehistory Decoded

Precession would likely have developed early in the Neolithic period to support a farming calendar. Specifically, he predicts the definition of sets of four zodiacal constellations corresponding to those behind the sun on the four solstices/equinoxes that can be used to define world ages, beginning with the age of Gemini around 6,000 BCE. However, his arguments should apply equally to the Palaeolithic era since Palaeolithic hunter-gatherers would have been as dependent on the seasons as Neolithic farmers. Moreover, De Santillana and von Dechend (1969) claim precession is encoded in many ancient worldwide myths, which also suggests it was known at a very early time.

Despite these arguments for very early discovery of precession, it is only known for certain that Hipparchus noticed precession in the 2nd century BCE. But, this should be considered the latest time by which precession was discovered, not the earliest. Magli (2004) discusses strong evidence for prior knowledge of precession, including in Bronze Age Egypt, Mesopotamia and the Indus Valley.

Although the constellations are human inventions, the brightest stars naturally form obvious patterns which are likely to be highly conserved across cultures. This led Frank and Bengoa (2001) and then D'Huy (2016) to suggest some of our most noticeable modern-day constellations, like Ursa Major and Orion, might originate in the Palaeolithic period. They concluded this after comparing commonalities in associated myths from widely separated cultural groups.

Hayden and Villeneuve (2011) argue that specialist astronomers in many Palaeolithic hunter-gatherer groups likely tracked the solstices and equinoxes. They came to this conclusion after reviewing, i) the research literature for evidence of good naked-eye astronomy amongst Palaeolithic people, and ii) performing an ethnographic review of extant hunter-gatherer (HG) groups from around the world. They found that most modern-day HG groups maintained important communal knowledge of astronomy and that a significant fraction carefully tracked the solstices and/or equinoxes. Moreover, they found that this custom was much more prevalent in what they called 'complex' HG groups.

Regarding evidence for good naked-eye astronomy amongst Upper Palaeolithic HG groups, Hayden and Villeneuve reviewed the work of Marshack (1972), Rappenglück (2004), and Jègues-wolkiewiez (2007). Marshack's early work focussed on interpretation of repeated carved lines and marks on many artifacts from the Upper Palaeolithic era.
of days while counting left to right along the lower row and back along the upper row gives 29 days. Of course, the synodic lunar month is very close to 29.5 days which means that counting the days of successive lunar months will usually give alternating counts of 29 or 30 days.

Amongst Rappenglück ’s (2004) work, probably the strongest indication of an interest in astronomy in the Upper Palaeolithic are groups of painted dots found in well-known caves, such as Lascaux, that he interprets as representing the Pleiades star cluster (see Figures 6a and 6b). While the positional correlation between these groups of dots and the brightest stars in the Pleiades cluster is not very strong, these groupings are similar to contemporary symbols found painted on a Navajo Tipi, within a Hopi Kiva and on a Chukchi shaman's cosmographical map which Rappenglück claims represent the Pleiades.

In each of these cases from Marshack and Rappenglück there are clear associations between the abstract markings and neighbouring animal symbols or paintings that led both authors to suggest the animal symbols might represent constellations. Indeed, Rappenglück suggests they might even represent constellations similar to those we know today, including the bull as Taurus. Using a statistical analysis Sauvet and Wlodarczyk (2008) find these Upper Palaeolithic animal paintings are correlated such that they often form clusters or groups with similar species of animal. For example, they note that paintings of horse, ibex and bison often appear together although this correlation is not perfect. Clearly, if these animal symbols do represent constellations, any correlations among them could help to identify the constellations they represent.
European Palaeolithic cave art is highly conserved and remained almost unchanged for 30,000 years in terms of subject matter and style. Clearly, it was an immensely important activity for Palaeolithic people. This suggests it was linked to a long-lasting mythology. As we also expect that some long-lasting myths are linked to constellations, we have a consistent set of assumptions; namely that Palaeolithic people studied the stars, associated them with myths and animals, and painted their constellation symbols on cave walls.

Jègues-wolkiewiez (2007) examined the apparent direction of numerous Upper Palaeolithic painted cave entrances in western Europe and found a very strong tendency for these cave entrances to align, or point, towards the latitude of the rising or setting sun on one of the solstices or equinoxes. Although there remain some questions about her cave selection and measurement methodology the strength of this correlation strongly suggests a special interest in the solstices and equinoxes.

Hayden and Villeneuve (2011) highlight the Lascaux cave entrance as an example. This cave entrance opens into the Hall of Bulls, so named for the series of paintings of bulls on its walls. It also happens that this cave entrance faces quite closely towards the setting of the sun on the summer solstice such that the sun illuminates portions of these bull paintings on this event. Yet, at the time it is thought these cave walls were painted, around 15,300 BCE, the summer solstice constellation is Capricornus, not Taurus. It is, therefore,
Synt: 'A constellation similar to Capricornus instead of Taurus. We can then understand why the bull symbol might have been chosen for the Hall of Bulls at Lascaux; it is perhaps so that the summer solstice constellation symbol, i.e. the bull symbolising pseudo-Capricornus, is illuminated as the sun sets on the summer solstice around 15,300 BC.

However, Sweatman and Coombs (2019) go much further than this. They find an extremely strong correlation between the radiocarbon dates of well-dated animal paintings in European Palaeolithic caves and their corresponding ‘zodiacal date’. The zodiacal date is the date range expected for an animal symbol if it was painted when its respective constellation corresponds to one of the solstitial or equinoctial constellations. Considering it is already suspected these symbols might represent constellations, the strength of this correlation suggests we can be almost certain this hypothesis is correct.

Presumably, Palaeolithic HGs simply painted many of the respective animal symbols for the solstitial and equinoctial constellations at the time on the cave walls. This also helps to explain the strong correlation among the groups of painted animal species observed by Sauvet and Wlodarczyk (2008); these groups are likely caused by precession of the equinoxes. This adds further support to the view that Gurshtein’s (2005) prediction of a Neolithic zodiacal dating system using the solstitial and equinoctial constellations should be extended backwards to the Upper Palaeolithic.

In summary, we can expect that many Upper Palaeolithic HG groups, especially ‘complex’ ones, were keen naked-eye astronomers focussed on observation of the solstices and equinoxes mainly for calendrical purposes.

2.3 Origin of the Ancient Greek constellations

Considering the work of Sweatman and Tsikritsis (2017a) regarding an astronomical interpretation for Göbekli Tepe relies on identifying some of Göbekli Tepe’s animal symbols as precursors to the Greek constellations, it is worth first reviewing current understanding regarding their origin.

Modern set of Western constellations is based substantially on the ancient Greek...
constellations in ancient works by Homer and Hesiod (Lattimore, 1951; Lattimore, 1965; Evelyn-White, 1936). Although the earliest surviving manuscripts of these epics date to the 8th Century BCE, they are thought to describe events from the preceding millennium. In particular they allude to Orion, Bootes, Ursa Major and the Pleiades and Hyades, as well as specific stars.

As for the ancient Greek zodiacal constellations, they are also listed in the Babylonian MUL.APIN text, also from the mid-1st millennium BCE (Krupp, 2000), although they are not described with the same level of detail as in Ptolemy’s Almagest. However, it is thought by some scholars that these surviving cuneiform texts are probably copies of older ones from the end of the 2nd millennium BCE.

It is, therefore, often suggested that the Greeks combined the Babylonian zodiacal constellations with disparate non-zodiacal constellations to create the complete set described by Ptolemy (Rogers, 1998a; Rogers 1998b).

While this is an attractive story for the origin of the Greek constellations, there is no clear evidence it is correct. In fact, it is obviously contradicted by Pseudo-Eratosthenes who recounts a myth recorded in a now-lost work by Hesiod (which therefore might date to the 2nd millennium BCE) about the deity Orion (Condos (1997));

"Orion went away to Crete and spent his time hunting in company with Artemis and Leto. It seems that he threatened to kill every beast there was on earth; whereupon, in her anger, Earth sent up against him a scorpion of very great size by which he was stung and so perished. After this Zeus, at one prayer of Artemis and Leto, put him among the stars, because of his manliness, and the scorpion also as a memorial of him and of what had occurred."

Thus, it appears the Greeks might have known of at least some of their zodiacal constellations by the 2nd millennium BCE. Recent reviews emphasize this uncertainty. For example, Kechagias and Hoffman (2022) state

"... the origin of the 48 ancient constellations of the Almagest remain largely enigmatic in contrast to the modern southern constellations, ... There has been much speculation about possible origins in ancient Mesopotamia and ancient Egypt (Boll 1903) with the first hypothesis being more popular due to the panbabylonism in the first half of the 20th century."

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In the Old Babylonian period (19th‒16th centuries BC) the system of Mesopotamian constellations already existed, apparently in almost complete form. On the whole, we can find at least 13 constellation names in these sources. Most of them are written in Sumerian (with sumerograms) and only 10 (less than a quarter) in Akkadian (syllabically).

Unfortunately, Kurtik does not reveal exactly which constellations are referenced, or whether any of them are similar to the Greek 48. Nevertheless, he does highlight once again the link between constellations, animal symbols and religion in Mesopotamia. For example, Kurtik (2019) writes;

"Already in the Old Babylonian period (probably even earlier) the constellations in Mesopotamia were worshipped as deities ... Names of stars, for example, in-zu-um (= muluz3), in the Old Babylonian period were also the names of gods."

These associations between constellations and deities are explicit in the Mul.Apin text, which possibly dates to the late 2nd millennium BCE. Kurtik (2019) discusses two specific early examples from the Old Babylonian period;

"This article is devoted to cuneiform sources shedding light on history of Mesopotamian constellations muluz3 ("The Goat") located in the area of modern Lyra, mul duGula, a goddess connected with muluz3, and mulur.gi7 ("The Dog") located in Hercules."

Since many Old Babylonian period star and constellation names are Sumerian, it is likely that the association of animal symbols, constellations and deities is a pre-historic tradition. As we already expect that some very ancient and widely-dispersed myths, perhaps from the middle Palaeolithic, are also linked with constellations and specific animal symbols (Norris and Norris (2021), D'Huy (2016)), we can expect that this practice is quite common throughout history. Given Góbekli Tepe's location in upper Mesopotamia and its suspected role in the Neolithic revolution, along with the association between shamanism and astronomy (Krupp, 1999), this further justifies the view that Góbekli Tepe's animal symbols probably represent constellations.

### 2.4 Inter-cultural Master-of-Animals and sunset symbols

Evidence for much earlier knowledge specifically of some of the Greek zodiacal constellations is found in Near Eastern artistic works. In particular, Greek zodiac-like
For example, Figure 7a shows an ornamental weight in the shape of a 'handbag' belonging to the Jiroft Culture (Iran) from the mid-3rd Millennium BCE. It displays two Greek zodiac-like symbols, felines and scorpions, surrounding a Master-of-Animals motif. This artistic style and these symbols are known as 'intercultural' because of their widespread appearance across the Eastern Mediterranean and Near East throughout the Early Bronze Age (Counts and Arnold, 2010).

In terms of a zodiacal date, Scorpius is the autumn equinox constellation from around 3800–2300 BCE, while Leo is the summer solstice constellation from around 4000–1500 BCE.

Figure 7. Ancient Iranian Jiroft 'handbag' with Master-of-Animals symbol, circa 2500 BCE (a, from Wikipedia, CC-BY-4.0). Uruk Vase, Mesopotamia, circa 3500 – 3000 BCE (b, from Wikipedia, CC-BY-4.0). Bottom of Figure 2.9 from Woods (2010) showing proto-cuneiform time-keeping symbols that resemble a sunset symbol turned on its side (c). The 'akhet' Egyptian hieroglyph for 'horizon' (d). Early Sumerian pictogram for the sun (e, from the Encyclopaedia Britannica Online).
Thus, this scene is consistent with Gurshtein’s prediction for an early system of zodiacal dating, but here only two, not four, animal symbols are seen. Other popular animal symbols among Jiroft artefacts include bulls, ibex, birds of prey and snakes (Basafa and Rezaei, 2014; Salajeghe et al., 2018). Note that Taurus is the spring equinox constellation from around 3800 – 1700 BCE, and earlier work has suggested the ibex likely represents a constellation similar to Aquarius (Hartner, 1965; Avner et al., 2017), which is the winter solstice constellation from around 3700 – 2000 BCE. Moreover, before 3800 BCE the autumn equinox constellation is Sagittarius which, as we shall see, can be associated with a bird-of-prey on Pillar 43 at Göbekli Tepe. Therefore, the most popular animals, except snakes, on these specific ancient artefacts can all be interpreted zodiacally. The snakes, as will be shown later, might have a different meaning.

Similarly, Figure 7b shows the Uruk Vase. As its name suggests, it was recovered from the ancient Sumerian city of Uruk and is thought to date to the late-4th millennium BCE. At the top of the vase, supported by symbols that can be interpreted as setting suns, are two animal symbols; a lion and an ibex. Once again, this vase can be interpreted as providing a date using precession of the equinoxes in line with Gurshtein’s prediction. Moreover, these potential sunset symbols on the Uruk Vase suggest a reason for the shape of the previously-mentioned stone weight; the semi-circular ‘handbag’ shape might allude to a sunset. More examples of the potential existence of an ancient zodiacal dating system like that on the Uruk Vase within widely separated Neolithic, Bronze and Iron-age cultures are given elsewhere (Sweatman, 2020).

Figure 8 shows further examples of the inter-cultural Master-of-Animals symbols from a wide range of Near Eastern Iron and Bronze Age cultures. In nearly all cases, the animal symbols are consistent with Gurshtein’s prediction for a system of zodiacal dating based on precession and either the Greek zodiac or a Palaeolithic zodiac deduced by Sweatman and Coombs (2019). There are only two exceptions here; i) there are some cases where the Master/Mistress grasps snakes instead of zodiac-like animal symbols, and ii) the elephant on the Pashupati Seal from the Indus Valley has not yet been deduced to be a zodiacal symbol. However, proboscideans are a popular symbol in European Palaeolithic cave art, so it is possible the Indus Valley were using a variant of an ice-age zodiac.
Figure 8. More inter-cultural Master-of-Animals symbols. a) Classical Greece where the Mistress-of-Animals is recognised as Artemis, ~ 500 – 700 BCE; b) Minoan Crete, ~ 1,700 – 1,400 BCE; c) Seal stamps, Indus Valley, 2,400 – 1,500 BCE; d) Ur, Sumer, ~ 2,500 BCE; d) the Gebel-Al-Arak knife, Egypt, ~ 3,500 – 3,200 BCE; e) Hierakonpolis in Egypt, ~ 3,400 BCE. (All images from Wikipedia, CC-BY-4.0)

The possibility that a zodiacal dating system based on precession existed before the Bronze Age in Mesopotamia is further supported by the existence of many seal scrolls that are often covered in zodiac-like symbols. These symbols might have played a pivotal role in the development of writing, as they are thought to be precursors to the earliest Mesopotamian hieroglyphs which eventually became cuneiform from the early 3rd millennium BCE onwards (Woods, 2010). It makes some sense that symbols that were already important, such as zodiacal symbols used for dating artefacts, might be some of the first ones converted to hieroglyphs, rather than simply using symbols of animals without any higher meaning. We see mainly the same animals on these seals; lions, bulls, ibex, but also fish (Woods, 2010). Possibly, in this case, the fish represent a constellation similar to Pisces which is the winter solstice constellation before Aquarius, i.e. before 3700 BCE. We also see that proto-cuneiform time-keeping symbols for ‘day’, ‘month’ and ‘year’,
Given the presence of the semi-circles, we can interpret the stone weight in Figure 7a as meaning 'epoch of the feline and scorpion', while on the Uruk Vase in Figure 7b we can read 'epoch of the feline and ibex'. This view aligns well with that of Hartner (1965) who interpreted 4th millennium BCE images of the 'lion-bull combat' zodiacally in terms of the constellations Taurus and Leo, respectively. To support his interpretation, he provided many examples of artefacts where the lion and bull can obviously be interpreted as constellations. For example, they might be set on a starry background, or have star-like inclusions on their bodies, or have exaggerated features with astronomical connotations. However, not all of the stone weights with an intercultural style that display a sunset-like shape, similar to that in Figure 7a, are adorned with zodiac-like animals. Therefore, more generally, these sunset-shaped weights likely have a range of astronomically-related meanings depending on the context.

To be clear, it is worth emphasizing that although the inter-cultural Bronze-Age animal symbols mentioned above might be zodiacal, they need not refer to constellations to the same level of detail as in Ptolemy's Almagest. A more realistic view is that they define a smaller set of simpler versions of those constellations. We can therefore view them as potential ancestors of the Greek constellations.

However, it's worth noting that the Master-of-Animals symbol is potentially much older than the 4th Millennium BCE. Figure 9 shows three Neolithic examples. In Figure 9a we see three stone plaquettes recovered from Tepe Guyan and thought to date to the 5th millennium BCE. The left-most of these likely shows another Master-of-Animals holding a pair of snakes. The middle Master is very similar, but now the serpent crosses its torso and reminds us of the Greek constellation Ophiuchus. Note a single star appears in the background and the head sports a long, curved beak. It also happens that Ophiuchus is the autumn equinox constellation briefly between 4,100 - 3,600 BCE. The rightmost figure is also similar but has added V-symbols in the background. Going back even further to Çatalhöyük and the 7th millennium BCE, we see a Mistress-of-Animals holding two leopards by the neck (see Figure 9b). Previously, Sweatman and Coombs (2019) deduced that the four kinds of plastered wall reliefs that appear in Çatalhöyük's lower levels are also consistent with Gurshtein's prediction. In this case, the leopard is associated with a constellation similar to Cancer, which is the spring equinox constellation at the time. Since the Mistress is often associated with fertility or thought to represent a solar deity linked with the spring equinox, it makes sense that she should appear together with the spring equinox constellation symbol (pseudo-Cancer) at this time.

Another update to my 'Lunisolar calendar' paper https://martinsweatman.blogspot.com/2023/11/another-update-to-my-lun...
Tepe Guyan, Iran, 5th millennium BCE

Sayburç, Turkey near Gobekli Tepe
~ 8000-9000 BCE?

Catalhöyük, Turkey ~ 7100-6000 BCE

Figure 9. Neolithic Master-of-Animals symbols. a) Stone plaquettes from Tepe Guyan (5th millennium BCE) possibly showing Ophiuchus as the Master-of-Animals; b) A Mistress-of-Animals from Çatalhöyük, 7,100 – 6,000 BCE; c) A Master-of-Animals from Sayburç near Gobekli Tepe. (Images a and b from Wikipedia, CC-BY-4.0, image c adapted from Özdoğan (2022), CC-BY-4.0).
on the surviving Greek set together with deductions made from Göbekli Tepe, it appears the origin of some of the Greek constellations might be traced far back into Upper Palaeolithic Europe. This view aligns with arguments given previously about the very early existence of some of the most obvious constellations and associated myths, such as Orion and Ursa Major, in the Palaeolithic.

Therefore, it appears that Göbekli Tepe could be a kind of bridge in time and place that connects European Upper Palaeolithic astronomical symbolism with Bronze-Age astronomical symbolism from the Near East. Indeed, Peters and Schmidt (2004) already suggested Göbekli Tepe represented a link between the zoomorphic symbolism of the Palaeolithic and the Neolithic. The importance of this site regarding the development of Neolithic culture in the Fertile Crescent after the Younger Dryas mini ice-age is already recognized. But the significance of its symbolism potentially amplifies its status even further.

2.5 The Younger Dryas impact and the Taurid meteor stream

A catastrophe at the dawn of civilisation has long been suspected by many, including Newton's successor, William Whiston, who suggested in 1696 that a comet was the cause of the Biblical flood (Whiston, 1696). In fact, the debate surrounding catastrophism versus gradualism can be traced at least as far back as Plato and Aristotle (Palmer, 2003). In recent decades, however, the idea has received a firm foundation in the form of the Younger Dryas (YD) impact hypothesis (Firestone et al., 2007). This idea proposes that Earth's interaction with a fragmented comet around 10,835 ± 50 yrs BCE is responsible for triggering the onset of the Younger Dryas mini ice-age, the extinction of many species of megafauna on several continents and the end of the Clovis culture in North America.

Although some earlier reports and review articles opposed the hypothesis, geochemical evidence for a cosmic impact event is now so strong it led Sweatman (2021) in a comprehensive review of the impact evidence to suggest the Younger Dryas impact hypothesis should now be considered a 'theory';

"...the overwhelming preponderance of the evidence from many of YDB sites over much half..."
Regarding research that claims to refute the Younger Dryas impact hypothesis, Sweatman notes that;

"Even work purported to contradict the impact hypothesis, when examined closely, actually supports it", and "Mistakes like these, and those above, ultimately lead to a loss of confidence in the objectivity of impact hypothesis opponents."

Powell (2022) later asked in his review whether the evidence supports Sweatman’s claim that the Younger Dryas impact hypothesis should be elevated to the status of ‘theory’,

"In this author's opinion, there is a strong case that it does. Moreover, it should not be forgotten that no other single theory can explain the Younger Dryas and its associated effects."

A more recent review, on the other hand, claims a “comprehensive refutation” the Younger Dryas impact hypothesis (Holliday et al., 2023). However, a careful reading of this very lengthy paper reveals that is a long series of weak or fallacious arguments. Therefore, the title is inappropriate as it contains no actual refutation arguments. It also fails to employ a key scientific principle; parsimony (a.k.a. Occam's razor). Instead, it treats all the evidence independently rather than as a cohesive whole. In fact, the geochemical evidence from the Younger Dryas boundary on four continents when considered together strongly suggests a widespread cosmic impact event near the Younger Dryas onset.

Note that the effects of this impact event are found to be on a global scale, including an airburst event around 150 kms south of Göbekli Tepe that destroyed one of the world’s first villages, Abu Hureyra (Moore et al., 2020), as well as extensive biomass burning (Wolbach et al., 2018a; Wolbach et al., 2018b). Evidence for the latter in the region around Göbekli Tepe can be observed as thick layers of micro-charcoal in Lakes Akgol and Van, only a few hundred kilometres from Göbekli Tepe in Turkey, with compatible radiocarbon dates (Turner et al., 2010).

The culprit for this impact event is generally thought to be Taurid meteor stream which is associated with comet Encke (Napier, 2010; Wittke, 2013; Moore et al. (2023)). This meteor stream is the largest to affect Earth, although currently it is not the most intense due to its age and dispersion. Due to longitudinal precession of the Taurids many intense episodes of
the autumn Taurids currently emanate over the course of two months from the direction of Pisces – Aries – Taurus, due to apsidal (nodal) precession of the meteor stream they are expected to emanate from the direction of Capricornus – Aquarius – Pisces when Göbekli Tepe was occupied if their dispersion has remained unchanged (Sweatman and Tsikritsis, 2017a). However, we can expect their path was less dispersed 12,000 years ago than today.

2.6 An astronomical interpretation of Göbekli Tepe’s pillars

The preceding discussion provides ample motivation for decoding many of Göbekli Tepe’s symbols astronomically. Because the main focus of this work is to provide evidence for a lunisolar calendar system at Göbekli Tepe and other Taş Tepeler sites, and since this interpretation supports the work of Sweatman and Tsikritsis (2017a), it is essential that their interpretation is reviewed next.

Recall that in section 2.1 the disk on Pillar 43 was suggested to represent the sun and the animal symbols were suggested to represent constellations (see Figure 4). The preceding discussion provides some justification for this. If this is true, then the head and wings of this bird symbol must represent an asterism very close to the path of the sun. Using Stellarium (2022) with the Western constellation set, we find that the only asterism defined along the ecliptic with this geometry is the ‘bow’ of Sagittarius, also known as the ‘teapot’, viewed at sunset. The apparent fit of this constellation to the head and wings of the vulture, including the relative positions of the disk and the sun, appears to be very good (see Figure 4).

This choice orients the main panel and suggests that if the animal symbols represent constellations, they might be ancestral to some of the ancient Greek ones. In fact, Sweatman and Tsikritsis (2017a) show using Stellarium and the Western constellation set how the lower panel on Pillar 43 can be interpreted as a scene in the sky around the Scorpius constellation as the sun sets, with the disk representing the position of the sun relative to Sagittarius on the summer solstice. Pillar 43 can therefore be interpreted as displaying a date, 10,950 BCE to within a few hundred years, using precession of the equinoaxes.

Now consider the upper panel with three sunset-like symbols, each next to a small animal symbol (see Figure 4). Recall from section 2.4 how a sunset-like symbol is a known intercultural symbol which can be linked to both time-keeping and a system of zodiacal dating, especially when it appears with zodiac-like animal symbols. Recall also how the Master-of-Animals and associated animal symbols appear to have survived from the time of Göbekli Tepe through to classical Greece.
In this case, in precisely the same way as for the stone weight in Figure 7a, the semi-circular symbols at the top of Pillar 43 can be interpreted as giving the winter solstice and equinoctial constellations on the same date, represented by the three small animal carvings. Pillar 43 is therefore also consistent with Gurshtein’s (2005) theory, although it appears at Göbekli Tepe far earlier than he predicted. Actually, Pillar 43 displays more advanced astronomical knowledge than suggested even by Gurshtein, since he did not predict use of the precise position of the sun relative to any of the four constellations as a method to refine the date. He only predicted the use of four constellations to write an astronomical age. Providing the relative position of the sun allows a date to be expressed far more accurately than he expected.

Sweatman and Tsikritsis (2017a) argue the zodiacal date written on Pillar 43 likely corresponds to the summer solstice, rather than the winter solstice or either of the equinoxes, because that choice provides by far the closest date to the construction of Göbekli Tepe. The other choices give dates either very far into the past or very far into the future.

This interpretation, that associates animal symbols on Pillar 43 with Greek constellations (including the bending bird at the top left of Pillar 43 with Pisces) as they set on the western horizon, is supported by a compelling statistical analysis (Sweatman and Tsikritsis, 2017a; Sweatman and Coombs, 2019). Since we already expect an astronomical interpretation for the many reasons given earlier, the strength of the observed correlation strongly suggests this hypothesis is correct. To dispute this claim, one would need to show the statistical analysis is flawed. One way this might be achieved is to challenge the ranking table derived by Sweatman and Tsikritsis (2017a) that compares Göbekli Tepe’s animal symbols with Stellarium’s constellation patterns, since this is based on a subjective evaluation.

The interpreted date, 10,950 BC to within a few hundred years, is consistent with the Younger Dryas impact (Kennett et al., 2015), which provides an explanation for the headless man symbol, likely representing death, at the bottom of the pillar (see Figure 4). While this date precedes the oldest radiocarbon date obtained from Göbekli Tepe so far (which corresponds to the construction of the wall of enclosure D) by over one thousand years, this is not unexpected. As explained earlier, Göbekli Tepe’s origin could be much older than the earliest construction date for this enclosure wall. And, as was argued already in Section 2.1, we should expect to find precursors to the grand structures already uncovered (Enclosures A - D). Therefore, a period of ~ 1000 years between the Younger Dryas impact event and construction of these monumental structures is not unexpected if the Younger Dryas impact was a key event in motivating their construction. In any case, it is not unreasonable to find dates referencing important long-past events in cultic or religious buildings. Pillar 43 can therefore be viewed as a memorial to the Younger Dryas impact event. This view is consistent with Peters and Schmidt’s (2004) "cult of the deceased".
Prehistory Decoded

Now let's turn our attention to Pillar 33, which is embedded into the south-western portion of the wall of enclosure D (see Figure 1). This pillar features a pair of tall bird symbols on one face with a fox symbol on its other face (see Figure 10). Bunches of snakes emanate from the bodies and legs of these symbols, with their heads converging on the inner narrow face of this pillar. More V-symbols can also be seen on this narrow face. Clearly, the animal symbols cannot represent actual animals, since snakes are not known to naturally emanate from the bodies of animals. However, if these animal symbols represent constellations, then the snakes naturally represent meteors. Indeed, Pillar 33 can be viewed as a very nice picture of a meteor stream. But which one?
Figure 10. Sketch of Pillar 33 at Göbekli Tepe, enclosure D, showing the side with a pair of tall birds. The other side of the pillar shows a fox. Snake symbols emanate from these animal symbols, with their heads converging on the narrow inner pillar face.

Recall, from the top-left of Pillar 43, we expect the tall bending bird represents Pisces. The fox, on the other hand, closely resembles the northern part of Aquarius as it sets on the western horizon (see Figure 11).
Figure 11. Comparison of a fox symbol on Pillar 2 at Göbekli Tepe with the northern part of Aquarius.

As already mentioned, the Taurids are thought to have radiated from the direction of Aquarius and then Pisces over a span of a few weeks at the time Göbekli Tepe was occupied. Therefore, we can view Pillar 33 as a good picture of the Taurid meteor stream, the same meteor stream implicated in the Younger Dryas impact event. Sweatman and Tsikritsis (2017a) show how a few other pillars at Göbekli Tepe can also be interpreted within this theme of the Younger Dryas impact event.

Notroff et al. (2017) opposed an astronomical interpretation for Göbekli Tepe’s symbolism for several reasons, summarized below;

1. They argued that some pillars are not in their original positions and the special enclosures were likely roofed which would limit their use as observatories.

2. They suggested the gap in the date thought to be represented on Pillar 43 and the earliest radiocarbon date obtained so far for Göbekli Tepe (which is from mortar in the wall of enclosure D) is “extremely far-fetched”.

3. If the animal carvings at Göbekli Tepe do symbolise constellations, they doubted they could be related to the Ancient Greek ones.

4. They suggested the selection of pillars is arbitrary and others are ignored.

5. They indicated an alternative interpretation for some of the symbols, including the animals, the ‘handbag’ symbols on Pillar 43 and the headless man. They prefer an interpretation for Göbekli Tepe’s symbolism based on a presumed skull cult.

Sweatman and Tsikritsis (2017b) responded by claiming that Notroff et al. used spurious
2. Since the artwork on Pillar 43 is partially covered by the enclosure wall in which it is embedded, and it is admitted that many pillars have likely been moved or recycled, it is possible that Pillar 43 is much older than the radiocarbon date for this enclosure wall. And, as already discussed, a Palaeolithic origin for Göbekli Tepe was suggested by Schmidt (2010) and has not been ruled out by Kinzel and Clare (2020). Moreover, as argued above, a significant time gap between the Younger Dryas impact and the construction of Enclosure D, sufficient to allow for its architectural development, is entirely expected. Moreover, religious or cultic buildings that are much younger than the dates of events they reference are common. Therefore, the time gap of concern to Notroff et al. is of no concern here.

3. This point concerns the cultural decay or evolution rate for constellations and symbols. Notroff et al.'s view that constellations and their symbols decay far too quickly for constellations related to the Greek ones (which we use in the Western constellation set) to be observed at Göbekli Tepe is unsubstantiated and contradicted by evidence discussed above. For example, as discussed earlier, it is known that European Palaeolithic cave art was highly conserved for nearly 30,000 years, and there is strong evidence these animal symbols might symbolise constellations. Moreover, other research suggests some constellations, such as the Pleiades, Orion and Ursa Major, might be extremely old with an origin far into the Palaeolithic. Thus, a range of evidence suggests the decay rate for some constellations can be extremely slow. In addition, it appears that the meaning of some symbols, such as the Master-of-Animals and the sunset-like semi-circle, survived from the time Göbekli Tepe was occupied to the Bronze Age (see Figures 7, 8 and 9). Schmidt (2011) suggested similar connections for some of the animal symbols. Thus, if some symbolic connections are deemed possible over this timespan, similarities in constellations are plausible. Moreover, considering Çatalhöyük (roughly 7000 – 6000 BCE) appears to display similar symbolism (Hodder and Meskell, 2011; Sweatman and Coombs, 2019) and there is evidence some of the Greek constellations existed already in late Neolithic Mesopotamia (see Figures 7 and 8), the time gap to be bridged is rather small, and possibly just a few millennia. This time gap might be closed with further research into this period. In any case, Sweatman and Tsikritsis (2017a) do not claim the constellations and symbols they identify at Göbekli Tepe are identical to the Greek ones in Ptolemy’s Almagest. For example, they associate the vulture/eagle to the teapot asterism of Sagittarius and the fox to the northern part of Aquarius. Thus, it is clear their hypothesis incorporates the decay of constellations and their symbols with time.

4. This is wrong. The astronomical interpretation is developed logically and supported by

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astrochronological interpretation described here since it is very efficient, for it can explain a lot
of the fine details in the symbolism with relatively few inputs. This is the most important
signal of a good theory. See the conclusions at the end of this paper for a discussion of this
point.

Therefore, with the symbolism of enclosure D at Göbekli Tepe likely referencing the Younger
Dryas impact event, circa 10,800 BCE, we should consider to what extent this event
motivated the construction of Göbekli Tepe and the role the Younger Dryas impact played in
stimulating the Palaeolithic-Neolithic transition in this region.

3. Lunisolar calendar systems at Taş Tepeler sites

The previous sections provide the background information needed before evidence for
lunisolar calendar systems at Taş Tepeler sites is discussed. However, first it is useful to
briefly review more recent lunisolar calendar systems. After that, evidence for knowledge of
lunisolar calendar systems at Göbekli Tepe and Karahan Tepe are discussed.

3.1 Ancient lunisolar calendar systems

Many ancient cultures used calendars to regulate their important civic occasions, such as
ceremonies and feasts (Stern, 2012). Due to seasonality of resources, solar calendars were
popular. Indeed, the Gregorian calendar we use today is solar as it maintains the equinoxes
and solstices at specific fixed days in the calendar. The twelve months of the Gregorian
calendar, however, likely have their origin in a much earlier lunar or lunisolar calendar since
there are twelve synodic lunar months in a tropical solar year.

In fact, a tropical solar year currently consists of 365.242 days while a synodic lunar month
contains only 29.5306 days. Therefore, there are 365.242/29.5306 = 12.368 lunar months
per solar year, which equates to 12 lunar months plus 10.9 additional days per solar year.
This incommensurability has resulted in many different lunisolar calendar systems
developed by cultures across the world that attempt to respect both the lunar and solar
cycles. For example, many ancient cultures adopted accurate lunisolar calendars by
Another pertinent calendar is one used by the Ancient Egyptians. Their civic calendar is thought to have consisted of 12 months of 30 days each plus 5 epagomenal days, making a civic year of exactly 365 days (Stern, 2012). Darvill (2022) suggests the megalithic circle of Stonehenge encodes a similar kind of calendar through its numerous pillars, albeit with an additional quarter-day. These calendars are solar, but not lunisolar, since the lunar cycle is quickly lost and it is not commensurate with a single solar year. However, as the Egyptian civic year is around 0.25 days short of a seasonal solar year, their civic calendar lost 1 day every 4 solar years, approximately. This resulted in the seasons drifting by a complete cycle every 1508 years, known as the Sothic cycle. However, if we use 12 lunar months with an average of 29.5 days each instead, then we require 11 epagomenal days \((12 \times 0.5 + 5)\), rather than just 5, to complete the year, at least approximately.

Another early example of a lunisolar calendar is thought to exist at Yazilikaya next to the archaeological site of Hattusa in central Turkey (Zanger and Gautschy, 2019; Zanger et al., 2021). The lunisolar calendar there is interpreted to feature a 19-year Metonic cycle and is represented in terms of a long list of local deities. Included among them are both male and female solar deities that could be descendants of Neolithic precursors.

### 3.2 A likely lunisolar calendar system at Göbekli Tepe

We are now able to discuss the main point of this article, which is the likely existence of lunisolar calendar systems at Göbekli Tepe and Karahan Tepe. This system appears to be expressed clearly in terms of V-symbols, which are evident on Pillar 43 at Göbekli Tepe and elsewhere. To examine this issue, it is necessary to consider known cases of V-symbols found within the Taş Tepeler culture. The premise here is that these sites are contemporaneous and connected by a common culture that used similar symbols within similar meanings.

First let's summarize known cases of V-symbols on artworks found at Taş Tepeler sites. Most notably, many V-symbols are found on Pillars 43 and 33 at Göbekli Tepe. V-symbols are also found on a small, stone plaquette recovered from Göbekli Tepe (Dietrich et al.,...
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The 29 V-symbols in the top row suggest the counting of a lunar cycle with each V-symbol representing a single day (Gordon, 2021). However, just as for the bone tally stick found at Abri Mege at Tarjat (see Figure 5), a more likely interpretation is that this row of V-symbols can be counted as either 29 or 30 days, as follows. Counting right-to-left using the upright V-symbols, including the single V-symbol at the beginning of the row, gives 15. Counting back using the same symbols gives another 15, for a total of 30. However, counting back using the 14 upturned V-symbols instead (that look like Lambdas, Λ) gives a total of 29, since the single upright V-symbol at the beginning is omitted. Using this counting device, a lunar month can be either 29 or 30 days long, as expected. (Gordon, 2021).

Directly below the upper row of double V-symbols is a row of 11 square symbols. Given the V-symbol likely represents a single day, these square symbols likely have a different temporal meaning. If we take each square to represent a whole lunar month, then we have 12 lunar months in total. Essentially, we expect each square means ‘repeat the above count’. If we take a strictly alternating series of 29 and 30 days for each lunar month, then we have a total of 354 days.

Directly below the row of squares is a row of 5 more double V-symbols. This equates to 10 days. If we take these to be epagomenal days then we have a total of 364 days, which is approximately one day short of a solar year. However, there remains one more V-symbol carved in the centre of the bird. This particular V-symbol might be thought to be describing the eagle/vulture’s plumage, similar to the lines on its wings. But it is possible that it also represents a single day, to complete a count of 365 days per year. Thus, this V-symbol appears to indicate the vulture/eagle signi...
Recall, in the previous section how the vulture/eagle is interpreted to symbolise the summer solstice constellation at the time of the event depicted, thought to be the Younger Dryas impact event. Also recall the moon, sun and H-symbols positioned at the 'neck' of Pillar 18, as though representing a necklace (see Figure 3). It appears that symbols positioned at the neck have a special significance.

This argument is given further weight by considering the Urfa Man statue, a similar male statue at Karahan Tepe and the wall carving at Sayburç. Urfa Man is a stone-carved statue recovered from excavations at Şanlıurfa, specifically Balıkkale Höyük, shown in Figure 13. The statue likely represents a human male (he is grasping his penis), or male deity. He is around two meters tall and has a double V-symbol at the neck similar to the eagle/vulture on Pillar 43 at Göbekli Tepe (Murdoch, 2021). Following the above discussion, we can expect the double V-symbol refers to time in some sense. Possibly, placement of this symbol at his neck indicates control or creation of time. Therefore, the Urfa Man might represent a time-controlling or time-creating deity, or perhaps a creator deity more generally. Very recently, a similar statue of a male grasping his penis with a clear V-symbol at his neck has been recovered from Karahan Tepe.
Recall also the Master-of-Animals at Sayburç, where a wall carving shows a male figure also grasping his penis with another double V-symbol at his neck (see Figure 9c). In this case, if the flanking animals are taken to represent zodiacal constellations, then this figure can also be interpreted as a time-controlling deity, or more generally as a prime creator deity, as for the Urfa Man statue. In this case, the animals might represent the much longer precessional timescale. Therefore, for the Sayburç carving the figure perhaps controls both the short timescale of days, i.e. the human domain indicated by the double V-symbol.
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Given the appearance of V-symbol necklaces on both the Urfa Man statue, a statue at Karahan Tepe and the Sayburç wall carving, it follows that the V-symbol at the neck of the eagle/vulture on Pillar 43 at Göbekli Tepe is probably not spurious or solely intended to indicate plumage as that would be inconsistent and confusing. More likely, the vulture/eagle's necklace also carries important information which reinforces the notion that it represents the summer solstice constellation.

Therefore, it appears that Pillar 43 encodes the summer solstice constellation and a date via precession of the equinoxes through two different but complimentary data structures. First, the system of animal symbols representing constellations along with the disc symbol representing the summer solstice sun on the main panel and the half-disc symbols representing the winter solstice and equinoxes on the upper panel. And second, through enumeration of a calendar structure on the main panel. Indeed, the structure of the 29 V-symbols is compelling evidence for counting a lunar cycle. Once this counting device is understood, the rest of the calendar structure follows very naturally. This suggests that the designers of Pillar 43 were determined that its meaning should not be misunderstood. Clearly, this was a very important artifact for them, which means it is likely to be important for understanding the motivation for Göbekli Tepe's construction and the cultural changes that followed in the region.

To summarize, it seems the number ‘11’ has as special significance at Göbekli Tepe. 11 is the number of lunar months in a year in addition to the first as well as the number of epagomenal days, of which one, the summer solstice, is special. We can write this data structure as follows;

1 lunar month = 29 or 30 days

+ 11 more lunar months = 354 days

+ 11 epagomenal days (of which one, the summer solstice, is special) = 365 days \( \pm 1 \) solar year

Although it seems relatively clear that this data structure was known at Göbekli Tepe, it is not yet clear how it was used. One possibility is that it is used for predicting future astronomical phenomena, such as the solstices and equinoxes (Gordon, 2021). However, given that the lunar cycle appears to be represented (by counting either 29 or 30 days), and that the total number of days (approximately) in a solar year was also known, it is possible that it was used to construct a lunisolar calendar, which would ensure the rest of the calendar structure follows very naturally. This suggests that the designers of Pillar 43 were determined that its meaning should not be misunderstood. Clearly, this was a very important artifact for them, which means it is likely to be important for understanding the motivation for Göbekli Tepe's construction and the cultural changes that followed in the region.
examining the plan of enclosures C and D. Figure 14 shows an elevated view of enclosure D at Göbekli Tepe. It is formed by 11 T-shaped pillars embedded within the sub-circular enclosure wall, with an additional pair of tall T-shaped pillars near its centre (see Figure 1a). Probably, it is no coincidence that the number of T-shaped pillars embedded within the enclosure wall equals the apparently special number 11. Moreover, by adding one or both of the central pillars to the count we obtain 12 or 13 pillars respectively, which equals the number of lunar months in each year when using a lunisolar calendar. Possibly, then, enclosure D was designed as a giant calendar (Gordon, 2021), with its pair of central pillars recording either a 12-month or 13-month year as required for a lunisolar calendar. The inner circle of enclosure C also has 11 T-shaped pillars, with a pair of tall pillars at its centre (see Figure 1a again) and, therefore, might have had the same function. Use of these megalithic enclosures in this way would be similar to the use of Stonehenge as a solar calendar (Darvil, 2022). However, the other rounded enclosures so far uncovered at Göbekli Tepe do not feature 11 T-shaped pillars. This indicates either that the other enclosures had a different function or that it is simply a coincidence that enclosures D and C both feature 11 T-shaped pillars in their inner walls.
Figure 14. Cupules on pillar tops from enclosure D at Göbekli Tepe (image courtesy of Claire Murdoch).

The tops of these pillars display many sets of dimples, or cupules. Such cupules are common at many megalithic sites across the world, including dolmens and stone circles, and are suggested to indicate the counting of astronomical phenomena (Magli, 2015). Figure 15 shows the top of Pillar 32. Although it is highly eroded, there appear to be 29 cupules, and possibly more. Perhaps, then, these cupules were used to count the days of the lunar cycle. However, the tops of other pillars are too highly eroded to count their cupules, and it remains unclear which phenomena they were used to count, if any. Perhaps important communal ceremonies and feasts were held within the enclosure on auspicious days such as the solstices and equinoxes, with the calendar counted using the cupules on the top of the Pillars.

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Let’s now return to Pillar 33 from enclosure D. This is the only other pillar at Göbekli Tepe known to exhibit V-symbols. Earlier, it was explained how Pillar 33 can be viewed as a picture of the Taurid meteor stream if the animal symbols on its broad faces correspond to the constellations Pisces (tall birds) and Aquarius (fox), with the snakes representing meteors. Indeed, it was suggested it shows how the Taurid meteor stream radiant moves from Aquarius to Pisces over the course of a few weeks. However, Pillar 33 also has V-symbols on its inner, narrow face (see Figure 16). On the right, 13 V-symbols ascend vertically, while on the left there are 14. As for Pillar 43, these are expected to represent the counting of days (Gordon, 2021). In this case, these symbols might count the duration of the meteor shower from the direction of each constellation as the radiant point moves over the course of nearly one lunar month; 13 days from the direction of Aquarius (the fox) and 14 days from the direction of Pisces (the tall bird). Thus, interpretation of the V-symbols as individual days is consistent across Göbekli Tepe and supports the earlier interpretation of Pillar 33.
Figure 16. Sketch of part of the inner face of Pillar 33, enclosure D, showing the V-symbols.

Also consider a small stone plaquette recovered from Göbekli Tepe (Dietrich et al., 2019). It displays a vertical series of 6 V-symbols between two long serpentine arrow symbols (see Figure 17a). Given the interpretation of Pillar 33, it appears this stone plaquette records another meteor stream, perhaps one lasting 6 days. This suggests Göbekli Tepe was used as an observatory. Given the apparent focus on the Younger Dryas impact via Pillar 43 and on meteor streams via Pillar 33 and this plaquette, it is possible that Gobekli Tepe’s enclosures were used for ceremonies linked to these events, as well as other astronomically-related events such as the solstices and equinoxes.
Finally in this section, we can interpret a bone plaquette from Dja’de el-Mughara (Kodaş et al., 2022), which is about 60 kms south-west of Göbekli Tepe, circa 9,000 BCE, as a lunar calendar (see Figure 17b). The plaquette is divided into four sections by crossed incisions. The 4 sections have 3, 8, 10 and 8 dimples respectively, plus an extra hole. The dimples could be used to count the days of a lunar calendar as follows. 3 is the number of days each lunar month that the moon is effectively invisible (the new moon). This leaves 26 or 27 days of visibility. If we take 26 days, this can be constructed from a waxing phase of 8 days, a symmetric phase of 10 days wherein the moon is full, and a waning phase of 8 days. The hole might have been used to count the extra day for a 30-day lunar month.

Figure 17. a) Stone plaquette recovered from Göbekli Tepe potentially showing a meteor stream. b) Bone plaquette from Dja’de el-Mughara potentially showing a lunar cycle (adapted from Kodaş et al., 2022).

3.3 A possible lunisolar calendar system at Karahan Tepe

Let’s turn now to consider Karahan Tepe, another site belonging to the Taş Tepeler culture situated around 50 km east of Göbekli Tepe (Karul, 2021). Of particular significance is an 11-pillar structure carved directly out of the bedrock (see Figure 18). This 7 x 5 m structure...
slimmer and appears curved with a recessed inner border and therefore might once have formed a complete oval-shaped annulus. Several of the pillars elsewhere at KT appear to be highly fractured, so it is possible this 11th pillar is not complete. In fact, this 11th pillar is the only one not carved directly out of the bedrock; rather it is inserted into a little socket at its base, which emphasizes its special status.

Figure 18. an 11-pillar pool structure at KT hewn out of the bedrock. The 11th pillar is different to the other 10 and appears to be incomplete. Note the carving of a face looking over the pool.

The 11 pillars in the pool structure are of similar height and might once have supported a lid or roof, which would have also rested on the edge or lip of the pool. On the western edge of the pool, just under the lip, we see a detailed carving of an almost circular face projecting inwards. Like the 3-d sculpture of a predator on a pillar at Göbekli Tepe, this face is carved...
Diameter. This latter enclosure contains T-shaped pillars as well as seats or benches carved directly out of the bedrock. Possibly, this large enclosure was also roofed and appears to have been a communal meeting place or perhaps a large family home. Another possible pool structure, this time without any pillars, is carved into the bedrock just to the north-west and partly adjoins the 11-pillar pool structure.

Once again, we see the significance of the number 11. Recall at Göbekli Tepe 11 T-shaped pillars form enclosure D and the inner ring of enclosure C. Recall also the 11 square box symbols and 11 additional V-symbols on the main panel of Pillar 43 at Göbekli Tepe which, together with the row of 29 V-symbols, likely encode a calendar. Also recall how one of the 11 additional V-symbols on the main panel of Pillar 43 at Göbekli Tepe is apparently special and likely denotes the summer solstice.

Since this structure at KT also has 11 pillars, and one of them is quite different, perhaps it also encodes a lunisolar calendar system identical to the one discovered at Göbekli Tepe. But how? Obviously, the 11 pillars can immediately be interpreted as representing the 11 epagomenal days required to complete a solar year. Also, given its slimmer, rounded shape, we can interpret the 11th pillar as representing the summer solstice, which appears to have been counted as a special epagomenal day at Göbekli Tepe. But to count 12 lunar months we need an additional pillar or structure. Possibly, then, this is the role played by the circular face. If the circular face is taken to represent an entire lunar month, then the 11 pillars can be interpreted as representing 11 more lunar months using precisely the same data structure as on Pillar 43. Essentially, a more efficient encoding of the data structure on Pillar 43 is suggested where the 11 pillars have a dual role. To clarify:

Circular face = 1 lunar month = 29 or 30 days

+ 11 pillars = 11 more lunar months = 354 days

+ 11 pillars = 11 epagomenal days (of which one, the summer solstice, is special) = 365 days ≡ 1 solar year

This interpretation requires the carved circular face to represent an entire lunar month. Indeed, its circular profile reminds us of the full moon, and the carved face is reminiscent of our familiar ‘man in the moon’ meme. It should not be surprising if the people living at Karahan Tepe saw similar patterns in the moon’s craters that we do today. Indeed, the Babylonians also saw a ‘man in the moon’, although theirs was imagined standing and not

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4. Discussion

The previous sections present evidence for lunisolar and lunar calendar systems at Taş Tepeler sites that support an astronomical interpretation of their symbolism. Included in that astronomical interpretation is a record of both the date and mechanism of the Younger Dryas impact. Essentially, we can view Pillar 43 at Göbekli Tepe as a memorial to that event.

Given Göbekli Tepe's prominence at the beginning of the Palaeolithic-Neolithic transition which later influenced a much wider region, it is sensible to consider potential symbolic links between the Göbekli Tepe culture at Taş Tepeler sites and later cultures in the Fertile Crescent and in neighbouring regions. We should look for links especially with those nearby cultures with grand megalithic temples or astronomy-related religions, such as ancient Egyptian and Mesopotamian cultures. We should also consider the possibility that the Younger Dryas impact had an important influence on the Palaeolithic-Neolithic transition. These issues are discussed next.

4.1 Symbolic connections with later cultures

The basis of this astronomical interpretation is that the animal symbols on the broad sides of Göbekli Tepe's pillars can be interpreted as constellations, similar to those known by ancient Greek and Mesopotamian cultures. The possibility this similarity can occur simply by coincidence is thought by Sweatman and Tsikritsis (2017a) to be very small. If this correspondence is correct, then we can expect much more of Göbekli Tepe's symbolism was preserved. For example, it is possible that the lunisolar calendar system apparent at Yazılıkaya (Zanger and Gautschy, 2019; Zanger et al, 2021) inherited some knowledge from the one apparent on Pillar 43. It is also thought that a lunisolar calendar system was in use in Egypt before the civic calendar with 5 epagomenal days became accepted (Ruggles, 2015). It was also argued earlier that the intercultural Master-of-Animals and Potnia Theron symbols found across the ancient Near East might be descended from similar symbols found at Sayburç and Çatalhöyük. Moreover, another intercultural symbol, the semi-circle, which is often found in association with animal symbols and interpreted here as representing a sunset, also appears at Göbekli Tepe at the top of Pillar 43 adjacent to animal symbols with precisely the same interpretation.

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With the symbol at top left interpreted as a sunset and the belted anthropomorphic figure holding a raised club interpreted as Orion. The remaining figures can all be seen on Pillar 43. For example, the hawk and scorpion are similar to the vulture and scorpion on Pillar 43, while the bending bird and ibex are similar to the small figures at the top of Pillar 43 next to the sunset symbols (alternatively, the ibex might represent pseudo-Aquarius, as for the Uruk vase). Finally, the tall bending bird with snake in this scene is also seen on Pillar 43, where it is thought to represent a constellation similar to Ophiuchus. Note that Ophiuchus is the autumn equinox constellation briefly between 4,100 - 3,600 BCE, which is broadly consistent with the interpreted date of this inscription. Overall, there is a very high similarity in the symbols in the scene and the symbols on Pillar 43. It is very clear that the artist who carved the Gebel Djauti scene and the artist that carved Pillar 43 knew a similar astronomical code. Thus, Sweatman’s (2019) interpretation efficiently explains many more of the details in this scene than that of Darnell and Darnell (2002).

The possibility that astronomical knowledge was important in ancient Egypt is suggested by the very close alignment of the Giza pyramids to the cardinal directions. Magli (2004) states that,

"...it is worth noting that the astronomically anchored data coming from Giza (orientation of "air-shafts" and pyramids) together with the many astronomical references which are present in the Pyramid Texts do show beyond any possible doubt that astronomy was present in the Old Kingdom as a fundamental part of thinking (religion and knowledge)."

Furthermore, Brady (2015) argues the astronomically-related religion described in the Pyramid texts likely originated at a much earlier time. Therefore, it is reasonable to interpret some pre-dynastic Egyptian symbols, like those that Gebel Djauti rock shelter, astronomically.
Schmidt made several references to similarities between the symbolism of Göbekli Tepe and Egypt. For example, he compared the snake symbols at Göbekli Tepe with Wadjet and specifically the Uraeus symbol (Schmidt, 2011). Moreover, at Karahan Tepe several statues have been found that show animals, especially foxes (see Figure 20), riding on the backs of humanoid figures, which is similar to the common representation of Egyptian deities with animal heads. Such human-animal hybrids are often associated with shamanism (see Dietrich (2023) for example). But it should also be remembered that megalithic stone circles and shamanistic practices are both often associated with astronomy (Krupp, 1999; Magli, 2015). Given also the Egyptian deities Sah-Osiris and Nut are linked with the constellation Orion and the starry sky respectively (Pinch, 2004), we can propose that many other Egyptian deities ultimately might have an astronomical origin.
symbols at Göbekli Tepe also represent constellations, then we can cautiously associate many of the animal symbols at Göbekli Tepe with some of the oldest Egyptian deities.

Figure 20. Two stone statues found at Karahan Tepe, now displayed at Şanliurfa museum, showing a fox riding on the back of a humanoid. Other similar statues have also been recovered from Karahan Tepe.

For example, if we consider the main section of Pillar 43, we can tentatively make the following associations: scorpion -> Serket, wolf/dog -> Anubis, duck/goose -> Geb, the bending bird with curved beak -> Thoth, eagle or vulture -> Horus and/or Nekhbet. Furthermore, the numerous fox symbols at Göbekli Tepe -> Set, the popular bovine symbol -> Apis, Hathor and/or Bat, a feline symbol on Pillar 51 -> Seshat and/or Sekhmet, and a ram symbol on Pillar 1 can be associated with Khnum and/or Amun.

These associations suggest a system of constellations related to that known in classical Greece was known to pre-dynastic Egyptians and was associated with their earliest deities.

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Regarding the many snake symbols seen at Göbekli Tepe, ophiolatry is widespread among many ancient cultures. Within ancient Egypt, in addition to Wadjet there is Apep, a serpentine god of chaos. Apep was also the greatest enemy of Ra, the Sun god, and thus associated with darkness. This would accord well with the association of snakes with meteors at Göbekli Tepe. The Sun and Moon symbols at Göbekli Tepe on Pillar 18 can obviously be associated with Ra and Khonsu, respectively.

In ancient Egypt, Atum is the prime creator deity of the Heliopolitan Ennead, an early AE pantheon. In some AE texts, he is said to have created the world through the act of masturbation (New World Encyclopedia contributors, 2022). Perhaps, then, Atum and similar early prime creator or time-controlling deities in this region, evolved from the more ancient Urfa Man deity (which also resembles figures found at Karahan Tepe and Sayburç). Atum is also said to represent the sun specifically as it sets. Recall how the animal symbols at Göbekli Tepe are associated with Greek constellations as they set on the western horizon. Therefore, Urfa Man and corresponding male Taş Tepeler deities might represent male solar-creation deities that control time while the Mistress might represent a female solar-fertility analogue.

These potential symbolic connections between the culture at Taş Tepeler sites and ancient Egypt are supported by genetic analysis. Notably, Schuenemann et al. (2017) analysed the DNA of three New Kingdom mummies and found their ancestry is most closely associated with Natufian populations (about 50%) with some admixture with Neolithic Anatolian groups (about 30%) and Iranian groups (about 20%, presumably from the Zagros mountains). Therefore, it is possible that the symbolic connections mentioned above might be generated by more than just cultural diffusion, i.e. migration could be a contributing factor.

Along with symbolism, it is also possible that some ancient myths might retain information from the time of Göbekli Tepe. For example, zodiac-like creatures are popular in Mesopotamian mythology, including bulls, lions, scorpions and serpents. Notably, the Bull of Heaven is highly destructive and has been associated with the constellation Taurus (Black and Green, 1992). The earliest version of this tale, like the constellation names mentioned, is Sumerian. Similarly, the Sun is associated with the constellation Aries. Ultimately, in the Babylonian creation myth, the Enūma Eliš, Tiamat is slain by the El, thus extending the zodiac.

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Babylonian deity, Marduk, and falls to Earth causing further devastation. Thus, Mesopotamian and Egyptian serpent and bovine symbolism is consistent with the astronomical interpretation presented here involving the Taurid meteor stream. Clube and Napier (1982) already suggested ancient serpent and bovine symbolism in many cases is linked to comets, meteors and cosmic impacts.

Indeed, Peters and van der Sluijs (2016) argue it is likely that many widely dispersed catastrophic myths associated with fire and destruction from the sky, such as the Greek Phaethon myth, are inspired by historic cosmic impacts. In the specific case of the Greek Phaethon myth, as told by Plato in his Timaeus (Jowett, 1998), the destruction is said to be cyclic;

“There is a story, which even you [Greeks] have preserved, that once upon a time Phaethon, the son of Helios, having yoked the steeds in his father’s chariot, because he was not able to drive them in the path of his father, burnt up all that was upon the earth, and was himself destroyed by a thunderbolt. Now this has the form of a myth, but really signifies a declination of the bodies moving in the heavens around the earth, and a great conflagration of things upon the earth, which recurs after long intervals.”

This is an accurate description of coherent catastrophism. Recall how the Younger Dryas impact event is thought to be caused by the decay of a giant progenitor comet within the inner solar system, i.e. by coherent catastrophism. Of course, interpretation of myths is often uncertain, much like the interpretation of symbols. But, if a cosmic impact interpretation is correct for these myths, then the Younger Dryas impact, 10,835 BCE ± 50 years, is clearly a suitable candidate. Peters and van der Sluijs (2016) suggest more recent cosmic impacts might also play role. However, due to the wide dispersion of such myths they favour a more ancient source.

4.2 The Origin of Civilisation

Göbekli Tepe is clearly an important site within the Taş Tepeler culture of upper Mesopotamia. It is located in space and time just before the onset of the Neolithic revolution in the Fertile Crescent, yet remains of domesticated species of plants or animals appear to be absent. Cauvin had already theorized that this cultural transition was triggered by a change in cognition, rather than agriculture (Cauvin, 2000). His evidence included the...
monumentality', i.e. that this important cultural transition was influenced by the desire to build imposing monuments, like the large enclosures at Göbekli Tepe and Karahan Tepe (Kinzel and Clare, 2020). Once they are built, it is argued that they could act as a focus for communal activities, possibly cultic or religious in character, that would attract a growing population.

Probably, we should consider cultural changes in both monumentality and artistic symbolism together as part of the same package. If we consider Cauvin's hypothesis based on artistic symbolism first, it is obviously flawed, or at least incomplete (Cauvin et al., 2001). He proposed the preponderance of bull and female symbols at this time played a significant role in the development of religion in the Fertile Crescent. Yet bull symbols are also prevalent in European Palaeolithic art and many female ‘Venus’ figurines are also known from that period (Nowell and Chang, 2014). And, in any case, European Palaeolithic cave art is at least the equal of the Early Neolithic artistic package of west Asia in terms of grandeur and finesse. Clearly, the change in cognition he suggests as the trigger for the Neolithic revolution had already occurred elsewhere. Nor could Cauvin explain why religion apparently developed and spread rapidly at this time within the Fertile Crescent. Realising this, he searched for a suitable environmental trigger, but could not find one that was adequate (Cauvin, 2000). For example, he suggested a potential role for an earthquake cluster at the beginning of the Holocene in upper Mesopotamia, but evidence was lacking. Again, he could not have known about the Younger Dryas impact (Firestone et al., 2007).

Çelik and Aayz (2022) agree that a specific ‘fracture in cognitive factors’ is not apparent to them either. Instead, they view Göbekli Tepe's symbolism more as a continuum from the earlier Palaeolithic period, recognising it likely carries important mythological and cosmological content,

"... they have exerted great effort both mentally and physically through mythological speculations that would even rival the Sumerians in order to make sense of their origins, of life and death."

In other words, while a change in cognition is not immediately evident, a change specifically in the effort expended in mythical enquiry, or religion, is. They therefore only partially agree with Cauvin's hypothesis.

If we now consider monumentality, this is also an inadequate explanation for the Palaeolithic-Neolithic cultural transition since it merely moves the goalposts one further
foundations supporting a wooden frame (Bar-Yosef, 1998). There is little hint of Göbekli Tepe's megalithic monumentality or accomplished symbolism in this pre-cursor culture prior to the Younger Dryas onset. That is, if we did not know of any Taş Tepeler sites, their grand monumentality and symbolism would not be predicted based on earlier Natufian sites or later Neolithic sites in this region. This was the state of knowledge prior Göbekli Tepe's discovery. If, to overcome this difficulty, one then suggests this change in monumentality was triggered by a change in the effort expended on mythical enquiry, i.e. religion, then we have at least partially returned to Cauvin's theory. Again, we can ask what triggered this change in religion?

The proposal that the new religion apparent at Göbekli Tepe solely concerns a cult of the deceased, or ancestor worship, or a skull cult, seems also to be insufficient, since if this explanation were correct then we could expect to have observed this important cultural transition together with the construction of grand temple-like enclosures at a much earlier time in pre-history, because we can expect such cults to be relatively common.

This work suggests the Younger Dryas impact completes Cauvin's programme. It is probably the rare environmental trigger that Cauvin sought that led to the development of a new religion at the beginning of the Neolithic in the Fertile Crescent. Religion might already have existed elsewhere, for example in Palaeolithic Europe, but the Younger Dryas impact might have triggered a novel, catastrophic form in the Fertile Crescent (Sweatman, 2019). Fear is a powerful organising principle in human society and the Younger Dryas impact would undoubtedly have inspired great fear and awe. Thus, this event can provide the motivation for the grand construction projects of Göbekli Tepe and related sites. It is also a sufficiently unusual and rare type of event that it becomes easier to explain why this cultural transition did not occur at a much earlier time in pre-history. These ideas are in accord with Hayden's view on shamanistic secret societies and their role in shaping the development of communities, often through self-aggrandizement (Hayden, 2019).

Göbekli Tepe's discovery and the decoding of its artworks strongly supports this hypothesis. It appears that Göbekli Tepe's pillars, especially Pillar 43, are memorials to this great event which was retained in cultural memory for millennia via many myths.

5. Conclusions

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Archaeoastronomy, as a discipline, seeks to understand this phenomenon. Earlier work provided an astronomical interpretation for animal symbols on the broad sides of pillars at Göbekli Tepe that involved knowledge of precession. Sweatman and Tsikritsis, (2017a) provide a statistical argument that this interpretation is very likely correct based on comparison with constellations in Stellarium. A consistent theme for this interpretation is the Younger Dryas impact, a proposed global-scale cosmic catastrophe at 10,835 ± 50 yrs BCE. The novel calendrical interpretation described in this work both supports and extends those earlier arguments. It also contributes more generally to archaeoastronomical research on the origins of naked-eye astronomy and the ancient Greek and Mesopotamian constellations.

Specifically, lunisolar calendar systems are likely described at Göbekli Tepe and Karahan Tepe. Indeed, similar to Stonehenge and some other ancient megalithic circles, enclosures C and D at Göbekli Tepe could represent giant calendars where the number 11 has a special significance; it likely indicates the number of epagomenal days needed to complete a solar year (approximately), given 11 + 1 lunar months. The summer solstice appears to have been regarded as a special epagomenal day. In addition, V-symbols within the Taş Tepeler culture appear to denote the counting of days. Necklace symbols also appear to have great significance. On the Urfa Man statue, Karahan Tepe statue and Sayburç wall carving they appear to indicate time-controlling or creator deities. It would be interesting to see if these V-symbols occur also in Palaeolithic cave art.

Clearly, this astronomical interpretation for Göbekli Tepe’s symbolism relies on comparison with other symbols that are either known or suspected to also be astronomical in nature, including constellations in Stellarium, the Nebra sky-disc, specific artifacts from late Neolithic and Early Bronze-Age Mesopotamia and Egypt, and Palaeolithic cave art and figurines. The time difference between Göbekli Tepe and creation of these other symbols might lead one to question the validity of this approach, but evidence presented here suggests astronomical symbolism can have a very long lifetime, perhaps longer even than 50,000 years for some astronomically-related myths. Moreover, even if some of this symbolism is convergent rather than culturally transmitted, the correlations still constitute evidence, albeit of a weaker kind, of this astronomical interpretation. In fact, comparison of Göbekli Tepe’s symbolism with symbolism at other sites, such as Çatalhöyük, or with Palaeolithic art or with Bronze Age cultures, or with Shamanistic symbolism, is commonplace. Ultimately, if we are to decode Göbekli Tepe’s symbolism at all, then
between widely separated cultures, the method of comparison is essentially the same and necessary for scientific progress. This work is no different in this respect.

Nevertheless, the confidence we attached to any hypothesis that attempts to explain Göbekli Tepe’s symbolism, or any other scientific theory for that matter, should be proportional to its ‘explaining power’. That is, the more observations a hypothesis or theory can explain, relative to its inputs, then the better the theory. This is simply a statement of Occam’s razor, which is itself a statement about probability and therefore logic. The astronomical interpretation for Göbekli Tepe’s symbolism, including evidence for time-keeping and calendrical systems presented here, is suggested to be a good theory because it is very ‘efficient’, i.e. it can explain a great many observations with only a few inputs. That is, if we consider the Western constellation set in Stellarium, precession, the Younger Dryas impact and lunar and solar cycles as inputs, then we can consistently explain all of the following observations;

1. The precise selection and placement of nearly all animal symbols on the broad face of Pillar 43 at Göbekli Tepe in terms of a memorial to the Younger Dryas impact encoded using zodiacal dating. Sweatman and Tsikritsis (2017a) consider the correlation of animal symbols with known constellations highly unlikely to occur simply by chance. Gurshtein (2005) predicted exactly this kind of zodiacal dating system should occur by 6000 BCE. Göbekli Tepe indicates it existed already in the Palaeolithic era.

2. All the V-symbols and small boxes on the main panel of Pillar 43 in terms of a lunisolar calendar, which perfectly complements and supports the interpreted zodiacal date (#1).

3. The precise selection of animal symbols on the broad sides of Pillar 33 and Pillar 2 and the V-symbols on the narrow face of Pillar 33 in terms of a picture of how the Taurid meteor stream changes over the course of a few weeks.

4. The consistent astronomical interpretation of many symbols on Pillar 18, including some with obvious astronomical associations such as sun and moon symbols.

5. The number of T-shaped pillars in enclosures D and the inner ring of enclosure C at Göbekli Tepe and the number of pillars in the pool structure at Karahan Tepe in terms of lunisolar...
9. The identity of the four major kinds of zoomorphic wall relief at Çatalhöyük in terms of shrines dedicated to deities related to the solstitial and equinoctial constellations (see Sweatman and Coombs, 2019). The Çatalhöyük Potnia-Theron is thus associated with feline symbols because this links fertility (the Potnia Theron) with the spring equinox constellation at the time (pseudo-Cancer, represented by felines).

10. The same symbol for one of the four major kinds of wall relief (the bear (Türkcan, 2007)) occurs at Çatalhöyük with a circle on its belly, but at Göbekli Tepe appears at the top-right of Pillar 43 next to a semi-circular symbol (see Figure 21). This is naturally explained if this symbol represents a constellation similar to Virgo, since Virgo is the summer solstice constellation at Çatalhöyük (hence the full circle) while it is the spring equinox constellation at the time of the Younger Dryas impact (hence the semi-circle).

11. The meaning of many late Neolithic and Bronze-Age intercultural Master-of-Animals, semi-circular sunset-like symbols and related animal symbols in terms of zodiacal dating using precession. This includes Hartner’s (1965) observations on Lion-Bull combat symbols, and zodiac-like animal symbols at the top of the Uruk Vase and the Gebel Tjauti rock carving.

12. Semi-circular symbols in early Sumerian pictograms used for both units of time and the sun and similar semi-circular symbols seen on a wide range of artefacts from the Neolithic to the Bronze Age consistent with a system of zodiacal dating in terms of a picture of the sunset on the solstices and/or equinoxes.

13. The apparently strong correlation between Göbekli Tepe's animal symbols and the most ancient Egyptian deities in terms of an ancient constellation set.

14. The origin of theriomorphic forms of many ancient Egyptian and Mesopotamian deities in terms of their relation to constellations described with animal symbols similar to those at Göbekli Tepe.

15. The preponderance of widely dispersed catastrophic myths involving destruction by fire from the sky or by a solar deity in terms of the Younger Dryas impact and similar cosmic impacts.
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The appearance of monumental megalithic sites like Göbekli Tepe along with larger-scale communal activities that potentially contributed to triggering the origin of civilisation in the Fertile Crescent shortly after the Younger Dryas impact in terms of a new religion inspired by the impact.

Figure 21. Bear symbols from Göbekli Tepe and Çatalhöyük: a) down-crawling quadruped at the top-right of Pillar 43 at Göbekli Tepe; b) 3-d sculpture from Göbekli Tepe; c) one of four types of wall relief from Çatalhöyük (from Mellaart, 1967); d) bear seal stamp from Çatalhöyük (image from www.Catalhoyuk.com).

Of course, if the astronomical interpretation presented here is correct, it implies that astronomical knowledge and notation around the Palaeolithic-Neolithic transition was far in advance of what is generally recognised. Not only was precession very likely known in the Upper Palaeolithic, it appears it was also used to date important events such as cosmic impacts. Indeed, the Lascaux Shaft Scene shares many similarities with Pillar 43 at Göbekli Tepe, which suggests it could be a record of another cosmic impact event in southern France, zodiacally dated to around 15,300 BCE (Sweatman and Coombs, 2019). This proposed impact might explain an apparent two-millennium hiatus in the occupation of Aquitaine, south-western France, during the late-middle Magdalenian period, radiocarbon...
Acknowledgements

In section 3.2, text written in italic font expresses ideas originally communicated by Dr John Gordon (Gordon, 2021). I thank the reviewers for their helpful comments that significantly improved the manuscript and I thank Claire Murdoch and Alistair Coombs for their comments on the manuscript.

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Debunking YouTube's archaeoastronomy skeptics

Holliday et al. (2023) Gish Gallop: timing of the Younger-Dryas onset and Greenland platinum spike


Some YouTube commentators, like Milo Rossi of MiniMinuteman and Stefan Milo, have made ignorant comments about the astronomical interpretations...
Significance: Gobekli Tepe (GT) probably represents the origin of civilisation for most of the world today. Most of us are connected to it in some way, through language and religion (proto-Nostratic),

...