

# Evaluating the evidence for lunar calendars in Upper Palaeolithic parietal art

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# Evaluating the Evidence for Lunar Calendars in Upper Palaeolithic Parietal Art

April Nowell , Paul Bahn & Jean-Loïc Le Quellec

*In this paper, we examine the lunar calendar interpretation to evaluate whether it is a viable explanation for the production of Upper Palaeolithic parietal art. We consider in detail the history of this approach, focusing on recently published variations on this interpretation. We then discuss the scientific method and whether these recent studies are designed to address the research questions necessary to test a lunar calendar hypothesis. More broadly, we explore challenges related to inferring meaning in art of the deep past, the use of secondary sources and selecting appropriate ethnographic analogies. Finally, we assess claims that the lunar calendar interpretation documents the world's oldest (proto)writing system. We conclude that the lunar calendar interpretation as currently construed suffers from multiple theoretical and methodological weaknesses preventing it from being a viable explanation for the production of Upper Palaeolithic art. We further find that claims following from this interpretation to have discovered the oldest known (proto)writing system are unsubstantiated.*

## Introduction

Upper Palaeolithic parietal art is a term that encompasses a large and varied corpus of drawings, paintings, and engravings on the walls, ceilings and floors of caves and rock shelters, and more rarely open-air sites, throughout regions of Australasia, Africa and Europe. The vast majority of these images are concentrated between 45,000 and 12,000 years ago. They are commonly subdivided into figurative (e.g. animals, including humans although the latter are quite rare) and non-figurative images including lines, dots and other signs whose names suggest their morphology but not necessarily their meaning —e.g. ‘tectiforms’ (roof shaped), ‘aviforms’ (bird shaped), ‘reniforms’ (kidney shaped), ‘cordiforms’ (heart shaped) and ‘penniforms’ (feather shaped). In some caves, particularly in Spain, non-figurative signs occur in greater frequencies than the more visually salient images of animals.

In the roughly 150 years since the antiquity and significance of this body of art were recognized,

archaeologists have proposed multiple explanations for it, including that the images functioned as a type of ‘hunting magic’ whereby the ritual killing of images of animals would help Ice Age hunters successfully capture prey in the real world; as ‘fertility magic’ to ensure the continued fecundity of animals or people; as ‘art for art’s sake’ where the images were primarily designed to be aesthetically pleasing; as a means of information sharing and/or the visual components of storytelling, particularly to teach younger generations (see Nowell 2023); as symbols of male and female duality within a structuralist approach; as entoptic images produced during shamanistic trances; and as a way of transforming landscapes, thereby making ‘spaces’ into ‘places’ imbued with meaning (but see Conkey 1997, who argues against grand vitalistic explanations of Upper Palaeolithic art that hold true everywhere and in all phases). This search for meaning in parietal art continues with the recent publication of papers (Bacon *et al.* 2022; Taylor 2021) proposing that the associations between animals and certain

signs are best understood as lunar calendars. While solar calendars are based directly on the solar year (i.e. 365.242 days), a lunar calendar is a system of marking the passage of time by reference to the monthly cycles of the moon's phases (synodic months or lunations, i.e. 29.531 days). The most widely observed lunar calendar today is the Islamic calendar, while the Jewish calendar is lunisolar. Lunar calendars have previously been proposed to explain sequential markings on Upper Palaeolithic portable art (e.g. Jègues-Wolkiewicz 2014) and the placement of a series of pits in Mesolithic Scotland dating to *c.* 10,000 bp (Gaffney *et al.* 2013).

There has been a renewed interest in lunar calendars as an explanation for parietal art from the Upper Palaeolithic (see, for example, Bacon *et al.* 2022; Rappenglück 2014; Taylor 2021). The reasoning behind this proposed interpretation is that hunter-gatherers are dependent on the animals in their environment for their livelihood (though it should be noted that plant foods may be of overwhelming importance in hunter-gatherer diets: Milton 2000; moreover, it has long been noted that the animals predominantly depicted in Palaeolithic art are not those which formed the bulk of the diet: Bahn 2016, *contra* Bacon *et al.* 2022, 1). It is argued that any tool that would allow humans to predict more accurately the behaviour of their prey (e.g. mating, birthing and spring and autumn migrations) would significantly increase their likelihood of survival. A calendar based on lunar months (due to the saliency of the waning and waxing of the full moon) is assumed to have fulfilled that function. Through 'art' (i.e. visual imagery), this knowledge could be stored outside the body to instruct future generations. In this paper, we examine the lunar calendar interpretation to evaluate whether it is a viable explanation for Upper Palaeolithic parietal art. First, we consider in detail the history of this approach, focusing on recently published variations on this interpretation. Then we discuss the use of the scientific method by these authors and whether their studies are designed to address the research questions necessary to test a lunar calendar hypothesis. Next, we explore issues of relevance to any study of meaning in Upper Palaeolithic art drawing on examples from these studies. Finally, we examine the larger implications of the lunar calendar interpretation for (proto) writing as argued by Bacon *et al.* (2022).

### **Celestial bodies, lunar calendar interpretations and Upper Palaeolithic art**

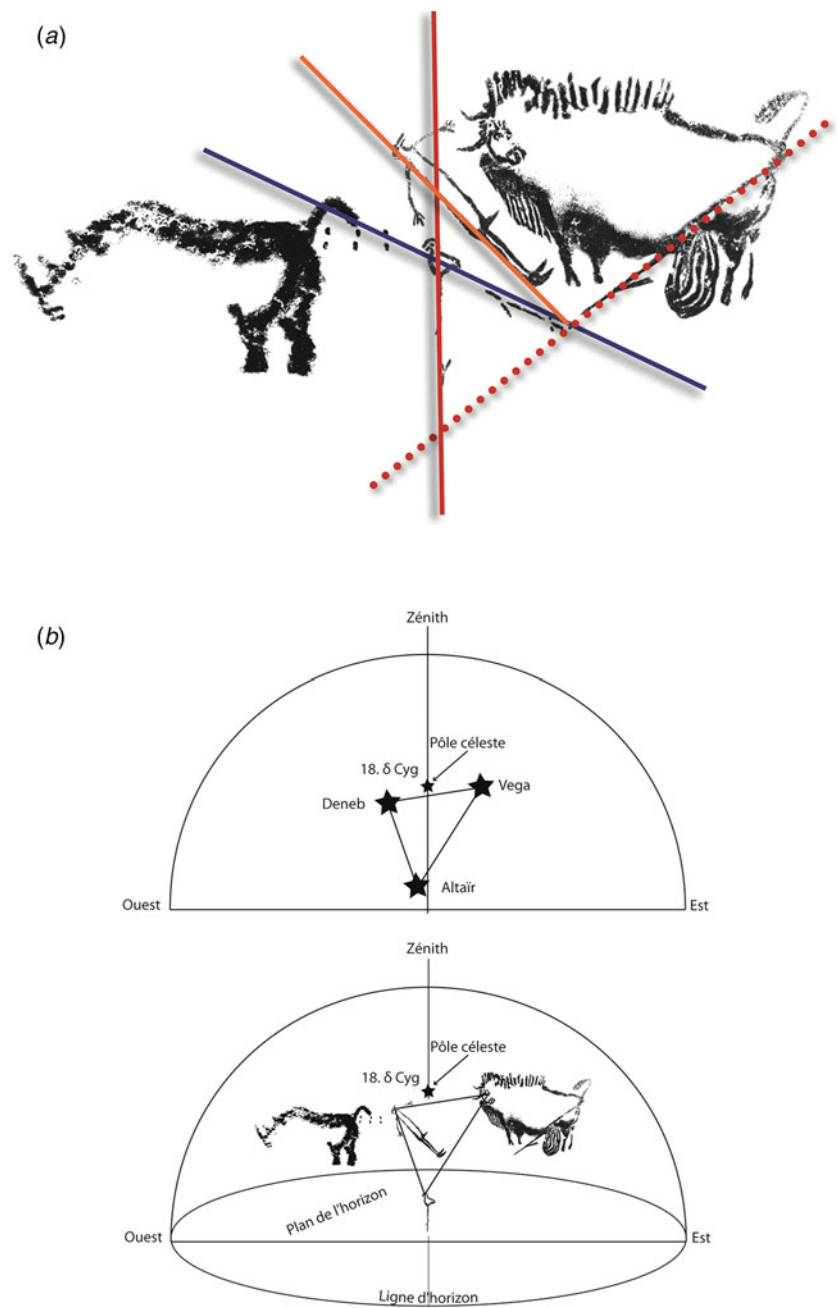
The exploration of possible links between Upper Palaeolithic art and celestial bodies generally and

lunar calendars more specifically has a long history. This approach includes interpreting specific images as celestial objects or demonstrating the passage of time either through reference to (1) seasonality purportedly depicted in an animal's appearance or behaviour, or (2) supposed notation systems.

#### *Images related to celestial objects*

One of the earliest interpretations of Upper Palaeolithic art, even before its official acceptance by the scientific community, was that the animals that decorated the cave walls might represent constellations (Ollier de Marichard 1868, 101–2). Since then, this interpretation has regularly reappeared in the literature. For example, in 1967, Charles Morse Huffer, Frederick Trinklein and Mark Bunge proposed that certain Palaeolithic paintings probably represented asterisms (Huffer *et al.* 1967, 95) while in 1968, Franck Bourdier argued that 'the Palaeolithic decorated cave may have been the scene of a celestial cult, because of its tectiforms, its swirling compositions (sometimes in domed chambers) and its animal depictions, possible symbols of the sky (bull), the sun (horse), or renewal (deer with shed antlers)' (Bourdier 1968, 103, our translation). A few years later, Christine Dequerlor (1975) claimed that a series of dots drawn on the right side of Lascaux's Axial Gallery represent the constellation of the Hydra. The same series of dots was interpreted by Árpád Ringer and Norbert Németh (2020, 249) more specifically as a lunar calendar linked to the menstrual cycle, in which the 'invaginated' part represents a uterus. Ringer (2020) also proposed a very complex and detailed astral and calendrical reading of Lascaux, in which the animals symbolize months, and the painted ensemble can be explained by a quadrennial cycle. He ended his study by calculating, on the basis of this reconstitution, that the cave was used 'between 16,800 and 16,500 BC'. He believed that this reading confirmed his theory, since this time-frame 'is close to the generally accepted AMS date for the art of Lascaux cave' (Ringer 2020). However, the latest date published for this cave is significantly earlier, around 21,000 bp (Ducasse & Langlais 2019).

Luz Antequera Congregado (1991) carefully studied the evolution of depictions of constellations in the history of Western art. She suggested that 'Palaeolithic people were probably the first to draw the forms of the constellations'. She found a 'surprising resemblance between the dots above the spine of one of the bulls in Lascaux cave and the position of the Pleiades in relation to Taurus' (1991). This idea was then taken up by Franklin Edge (1995; 1997) and by Michael Rappenglück (1997), among others.



**Figure 1.** (a) The lines drawn by Chantal Jègues-Wolkiewiez in support of her astral interpretation (drawing by JLLQ after Jègues-Wolkiewiez 2011, fig. 6); (b) Explanatory diagrams used by Michael Rappenglück in his thesis to present his astral interpretation of the ‘Shaft Scene’ (drawing by JLLQ after Rappenglück 1999, translated and modified).

A zodiacal reading of Lascaux cave in its entirety was put forward in the 2000s by Chantal Jègues-Wolkiewiez. In her (2011) discussion of its famous ‘shaft scene’ she argues that ‘the Bird-on-a-stick is in the axis of the world at 0° of azimuth north’ and that ‘the throwing weapons indicate the solstice directions of the sun at Lascaux’ (Fig. 1a). By contrast, Rappenglück regards the shaft scene as a celestial map (Fig. 1b), where the eyes of the bison, the man and the bird represent the three brightest stars visible in the summer night sky:

Vega, Deneb and Altair, drawing a gigantic triangle in space. Without explaining why the eyes of only these three figures represent stars (i.e. excluding that of the rhinoceros, which is also present in the shaft), he added that around 18,500 bp, this feature he referred to as ‘the summer triangle’ or ‘triangle of summer nights’ never descended below the horizon and must have been particularly visible at the start of spring—which would thus make it possible to date the paintings (Rappenglück 2002, 276). As for the bird on its post, this is supposedly

the North star posed on the axis of the world. He further contends that ‘the man-bird can be understood as a shaman in a state of ecstasy who journeys through the levels of the cosmos along the axis of the world and the Milky Way, and who reaches the domain of the other world, the zone of the circumpolar stars and the celestial pole  $18\ \delta\ \text{Cyg}$  which, around 14,500BC, was located in the Milky Way, and which thus indicates the real place of creation according to archaic mentality’ (Rappenglück 2002, 276. See also Rappenglück 2000; 2001; 2004a,b; 2009).

There are four primary weaknesses to these approaches. First, the same graphic configurations are often interpreted entirely differently by authors who contradict each other without any argument that would help one to arbitrate in favour of one reading *versus* another. Second, the basis for the assumptions made by these authors are often unclear. For example, in Rappenglück’s (2002) explanation of the shaft scene, why should the eyes of the man, bird and bison represent stars and why is the Milky Way, which plays a major role in the interpretation, not depicted? Third, these interpretations are based on graphic units arbitrarily extracted from the ensemble to give them meaning, or they rely on details selected *a priori*. Thus the ‘remarkable resemblance[s]’ (Rappenglück 1997, 3) are artificially constructed. Finally, even if we take all of the above claims at face value, of all the images that make up the corpus of Palaeolithic art, only a small fraction would be related to celestial objects.

#### *Seasonality in animal depictions*

In an alternative approach focusing upon calendrical systems rather than astronomy, Norbert Aujoulat (2005) sought clues to seasonality in the depictions of the horses, aurochs and stags which constitute more than 80 per cent of the animals in Lascaux Cave in France. The horse paintings were compared to their modern Przewalski counterparts, whose coat differs markedly in summer and winter. In the equid paintings, a denser colour on the flanks, a tail extended to the hooves and major corpulence supposedly indicate winter. The ventral ‘M’ motif, visible on certain Magdalenian horses, has been interpreted by other authors as marking the limit of colouring of a seasonally varying hide (Lorblanchet 2007, 194; Sauvet 1994, 97). Alexander Marshack (1972, 220–21) also suggested that the branched signs that accompany the ‘Chinese horses’ of Lascaux are bare branches that mark the end of spring or the autumn/winter. The aurochs paintings at Lascaux feature a very localized development of

shagginess, which indicates a summer coat, corroborated by the presence of a juvenile bovine behind the third bull in the rotunda. In stags, the clearest criterion of seasonality is the development of the antlers (Averbouh & Feruglio 2016), often disproportionately large in the paintings, and also the fact that the males regroup shortly before the courtship ritual, at the start of the autumn, a behaviour illustrated by several figures. Proponents of this approach try to demonstrate that each of the main periods of the calendar is evoked by a particular animal in the bestiary: ‘The horses mark the end of winter or the start of spring, the aurochs mark full summer, while the stags have been depicted with autumn attributes’ (Aujoulat 2005, 67–71). These are what Marshack called ‘chrono-factorised’ images. Moreover, the graphic sequence is claimed to follow ‘closely that seen in the annual variations in the animals’ behaviour’ (Aujoulat 2005, 112–13).

Marc Azéma extended these reflections by stressing that in the bison herds of Altamira and in a panel in Les Trois-Frères, the males, who are often pictured as highly animated, seem to surround a group of females in heat (identified by their raised tail). Together, these compositions from Altamira and Les Trois-Frères supposedly evoke the mating season. It is also possible to recognize allusions to this season in the bison panel of Fontanet and in the chamber of little bisons at La Mouthe, as well as in the ibex of the frieze of Le Roc-aux-Sorciers at Angles-sur-l’Anglin, the great ceiling of Rouffignac, and also the herds of stags at Massat and Lascaux, or the horses of Chauvet. All these works may evoke preambles to mating, which would be confirmed by the expression of seasonality in some parietal art (Azéma 2006, 500–501).

Unfortunately, the criteria used to support these interpretations are difficult to identify in the paintings, and even more so in engravings. Palaeolithic artists often emphasized deer antlers, going so far as to make them unrealistic and non-specific (i.e. drawn in such a way as to make it impossible to recognize the species) meaning they are not reliable indicators of seasonality. Where equids and bovines are concerned, it is primarily the density of the coat that is modified with the seasons, and their Palaeolithic depictions ‘do not generally make it possible to differentiate their summer and winter coats’ (Bouvier & Dubourg 1997, 238, our translation). As for the raised tail, it is only a definitive sign of pre-copulation among ibex, because ‘horses and bison (males and females) very often do this for a variety of insignificant reasons’ (Bouvier & Dubourg 1997, 238, our translation; Pigeaud 2000, 19). Among

horses, the positions of the tail are highly varied in nature, and most of those which indicate that the female is in estrus are the same as for urination or defecation, and they can also be adopted for getting rid of insects, or can precede a bucking (Waring 2007, fig. 20.10). Slender mammoths such as those in the cave of Roucadour have been interpreted as animals emaciated after a long winter and which had become hairless at the time of the first warmth (Delluc & Delluc 2004), but Michel Lorblanchet pointed out that the absence of tusks does not argue in favour of the naturalism of these figures (Lorblanchet 2007, 200).

In summary, indisputable indicators of seasonality are extremely rare, the most cited example being the 'hook-jawed' salmon of the Abri du Poisson, a characteristic of certain males during the autumn spawning (e.g. Peyrony 1932; Roussot 1984; White 2006). Moreover, since in the whole corpus of depicted animals there are absolutely no representations of birth or suckling, and practically no indisputable copulation scenes, 'it is therefore obvious that the representation of the seasons was not the main aim of the Palaeolithic artists' (Bouvier & Dubourg 1997, 243, our translation).

#### *Notational systems as indicators of the passage of time*

Taylor (2021), building on Marshack (1972), argues that Upper Palaeolithic peoples used phases of the moon to mark the passage of time and to record and predict animal behaviour key to their survival (mating, birthing and seasonal migrations), and that non-figurative images associated with the animals are the visual components of this calendrical system. For Taylor (2021, 223) one dot represents one day, and he claims that box shapes (commonly known as quadrangles) at Lascaux and elsewhere represent new moons: they 'were easy to paint and perhaps instinctively employed as they are for both geometrically organized calendars in the present and the Chinese character for moon. As pictorially represented with the Axial Gallery Pregnant Mare, each vertical set of boxes or elongated box represents a full moon while the shorter elongated box, or less nighttime illumination, marks the new moon'. Taylor (2021, 217) further suggests that the number 13 is important because it is 'the number of days leading up to the full moon from the first crescent (waxing) moon and when hunter-gatherers had specific hunting strategies for and success in harvesting deer, elk and other ungulates'.

Bacon *et al.* (2022) draw on three theories about cave art: (1) Francesco d'Errico (2002), who argued repeated lines might be an artificial memory system,

storing information outside the body; (2) Norbert Aujoulat (2005), who argued that the superposition of images at Lascaux (horse, aurochs, deer) related to the succession of reproduction and thus seasons; and finally (3) they may have been influenced by Steve Mithen (1991), who argued that the animal images were full of ethological information for teaching young hunters. These authors begin from two suppositions that they consider to be 'uncontroversial' (Bacon *et al.* 2022, 3, 5): (1) that the art records events and the passage of time; and (2) that lines and dots represent numbers. Like Taylor (2021), Bacon *et al.* (2022) focus on non-figurative signs in relation to animal figures. In particular, they focus on lines, dots and what they call 'Y-signs' (where one line branches into two lines). The hypothesis is that the association of certain numbers and certain animal species is probably significant/meaningful. The authors argue that knowledge of the yearly cycle of animal migrations, mating and birthing was of central importance to Upper Palaeolithic hunter-gatherers and thus it is reasonable to assume that the (non-figurative) number signs relate to the yearly cycle of migrations, mating and birthing. The authors (2022, 6) note that 'As none of the sequences in our database ... contains more than 13 marks, they are consistent with the 13 lunar months of a year. Hence, we hypothesize that sequences are conveying information about their associated animal taxa in units of months. In other words, they present ethological information as a seasonal calendar'. While the lines and dots are both said to represent months, the branching of the Y-sign is believed to symbolize the act of giving birth with one individual becoming two individuals or because the 'v' part of the Y-sign represents 'parted legs' (Bacon *et al.* 2022, 7).

Thus the rhythm of life in the Palaeolithic is said to follow a lunar calendar, and the authors imagine that this calendar must begin in what they call the 'bonne saison', in other words, springtime. They use the expression 'bonne saison', which they claim is a French zooarchaeological term,<sup>1</sup> to refer to when the winter ice melts and land is greener, roughly late spring. The dots and lines represent the number of lunar months since the beginning of the 'bonne saison' and the total number of months corresponds with the date of important events tied to game animals (spring and autumn migrations, mating and birthing/spawning).

To test their hypothesis, they recorded birthing, spring migration, mating season and autumn migration for eight living species (horse, bison, aurochs, reindeer, roe deer, elephant, birds and salmon) and

the corresponding time periods expressed in lunar months from the 'bonne saison'. Because of the difficulty of reconciling the lunar months with the solar year, the authors argue that Upper Palaeolithic peoples simply stopped counting in the winter months and started their calendar anew at the next 'bonne saison'. The birth period falls in months 1–2 for all species except for elephants and birds (months 1–3), and salmon (months 7–10). Mating is in months 2–5 for horses, months 4–5 for bison, month 4 for aurochs, months 4–6 for elephants, and later for reindeer (months 6.5–7.5) and red deer (months 5–7). Spring migration takes place generally in months 13 and 1 (i.e. during the 'bonne saison') at the beginning of the year or at the end of the preceding one, except for salmon migration that takes place in months 3–6 but does not occur for non-migratory animals, of course. The autumn migration takes place during months 5–7, aurochs are a little bit later (months 7–9) and likewise deer (months 8–9). The next step was simply to compare these dates with the numbers of dots and lines associated with the same animals in the parietal art. While none of the sequences correlated with spring or autumn migrations (figures of these data are not included), Bacon *et al.* (2022) argue they do correspond to mating and/or birthing events for each species.

Rappenglück (2014) made similar arguments almost a decade earlier, using some of the same examples. Rappenglück (2014), Taylor (2021) and Bacon *et al.* (2022) all emphasize the importance of the number 13 and attempt to link their calendars to events tied to animal behaviour such as mating, birthing and migration, but they differ in the details, for example whether the number 13 connotes days (Taylor 2021), weeks (Rappenglück 2014) or months (Bacon *et al.* 2022), whether the starting point for the calendar should be the 'bonne saison' (Bacon *et al.* 2022) or the new moon (Taylor 2021), and over the importance of 'box signs' (i.e. quadrangles) (Rappenglück 2014; Taylor 2021) versus Y-signs (Bacon *et al.* 2022). Rappenglück (2014), however, interprets quadrangles as months of time rather than the new moon (Taylor 2021). We now turn to an evaluation of the interpretations put forth by Rappenglück (2014), Taylor (2021) and Bacon *et al.* (2022).

## Evaluating the lunar calendar interpretation

### *Hypothesis testing*

The fundamental issue with these studies is that the interpretations the authors are proposing are not testable. None of these papers explicitly states a

hypothesis. In reference to Bacon *et al.* (2022), Magli (2023, 1, quoting Bacon *et al.* 2022, 6) writes, 'the authors need to establish if and what kind of a calendar was in use. The hypothesis is that the calendar had lunar months ... of 29 days. To decide the number of lunar months the authors make a biased choice: "As none of the sequences in our database contains more than 13 marks, they are consistent with the 13 lunar months of a year ..."; this procedure is scientifically incorrect because they are using the thesis as an hypothesis' (italics in the original). This observation is not a case of being pedantic. As a result of not articulating the correct research questions and concomitant hypotheses, the data necessary to test hypotheses that would allow them actually to address whether a lunar calendar was in use or not have not been collected and analysed. Rappenglück (2014) and Taylor (2021) do not use statistics to test for significant relationships of any kind. Although Bacon *et al.* (2022) do perform statistical tests, they are not actually testing the relationships that will allow them to support or refute the existence of lunar calendars in Upper Palaeolithic parietal art. We return to this point below.

### *Data sampling*

In order to test a hypothesis, it is necessary to collect a representative sample of the available data and not to exclude data that do not support it, thus biasing your results. Unfortunately, Bacon *et al.* (2022, Supplementary Material) exclude cases where the sequences of lines and dots in association with animals total 14 or more. In their database, they have one case each of 14 signs, 17 signs, 20 signs, 28 signs and 59 signs; two cases of 29 signs; and three cases of 16 signs, but they do not include them in their analysis. Thus, excluding all cases where the sequences exceed 13 biases their dataset in favour of the lunar calendar interpretation. Similarly, Bacon *et al.* (2022) only consider cases where there are lines and/or dots in association with animals. They do not include in their analysis examples of animals without these signs in association, nor do they consider dots or lines or Y-signs when they occur in isolation. They similarly do not consider therianthropes (animal–human hybrids) associated with the signs (Magli 2023). In order to test for meaningful relationships between sets of data one must look at all possible permutations of these relationships.

Finally, because in their database sequences of similar signs are overwhelmingly those comprising only three or four elements, Bacon *et al.* (2022) do not consider the other ethological events (i.e. spring and autumn migrations) that they had previously

said were important to hunter-gatherers in favor of focusing on mating and birthing. Although they looked for predictors of migrations and claim not to have found them (2022, 14), the migration data are not graphed and the implications of the negative results are not discussed.

#### *Reading ordinal level data*

Bacon *et al.* (2022, 1) write ‘The position of the <Y> within a sequence of marks denotes month of parturition, an ordinal representation of number in contrast to the cardinal representation used in tallies’. Ordinal data are a type of data where the variables have natural, ordered categories but the distances between the categories are not known. An example of ordinal data is categories such as ‘poor’, ‘middle class’ and ‘wealthy’. In the case of this modern example, we understand the natural order of the data, but with the non-figurative signs we do not. Bacon *et al.* (2022) do not consider whether the position of the Y-sign should be counted from left to right, right to left, top to bottom or bottom to top. Taylor (2021) suggests the signs should be read from right to left based on the trajectory of the moon in the night sky, but this is completely speculative.

#### *Causation versus correlation*

Bacon *et al.* write (2022, 13) ‘The first key message is that the birth periods are significantly well predicted by the position of <Y> ( $p < 0.0146$ )’ which they predict to be in position one, two or three based on each species’ birth months noted above. However, since the sequences with lines, dots and Y-signs in the database are short, the Y-sign is almost certain to be in positions one to three by definition. What the authors’ database shows more than anything is that the sequences of three or four lines/dots are by far the most common. This observation is not new and there are several possible explanations. The simplest is that notational systems up to four units are particularly useful; anything more needs to be broken into patterns such as ‘five’ and ‘six’ on dice (Trick & Pylyshyn 1994). But crucially, what the statistical tests do not tell us is the meaning of this pattern—what is being counted (if anything). As Magli (2023, 4) observes,

in Palaeolithic figurative art the vast majority of the additional signs is concentrated between 3 and 4 in number. This is a clear-cut case of a database in which a small but relatively acceptable set of data (tens to hundreds for each taxa, excluding [mammoths]) corresponds to a very small set of possible results; the results are very clearly not randomly distributed . . . *but the analysis cannot—and indeed, does not—furnish a proof of the proposed*

*interpretation, as many other interpretations could be ‘proved’ in the same way.* To put it in yet another way, the statistical analysis says ‘yes’ to both the questions: ‘are the numbers representing the third month of the phenological calendar?’ and ‘are the numbers saying that the artists saw three animals?’. (Emphasis added)

This critique is at the heart of the matter. As currently configured, the lunar calendar interpretation does not and cannot explain anything about Palaeolithic art and remains just one of many possibilities. What Bacon *et al.* (2022) have tested for and have demonstrated (selective data aside) is that the sequences of lines and dots associated with images of animals tend to be short—nothing less, but certainly nothing more. There is a correlation between animal images and length of the associated non-figurative sequence but this brings us no closer to causation, no closer to meaning (see also Dehaene 2024). When Bacon *et al.* write (2022, 1) ‘We demonstrate that when found in close association with images of animals the line and dot constitute numbers denoting months’ and that (2022, 1) ‘we also demonstrate that the Y sign . . . has the meaning “to give birth”’, this is not correct: the statistical analysis establishes a pattern which could be caused by many possibilities, not simply the interpretation asserted. Indeed, it is not clear that this motif has a particular meaning, or only one (see below).

#### **Interpreting Palaeolithic parietal art**

The studies assembled here raise a number of methodological issues common to all researchers interpreting Palaeolithic parietal art. In this section, drawing on examples in the work of Rappenglück (2014), Taylor (2021) and Bacon *et al.* (2022), we consider the challenges of inferring meaning from images created in the deep past, the dependence on secondary sources and the appropriate use of ethnographic analogies.

#### *Inferring meaning*

Inferring the meaning(s) of contemporary art is not always straightforward even with written records and living artists with whom to speak. Unsurprisingly, this task is more difficult still with art from the deep past. For example, it is not obvious that dots and lines in parietal art represent either days (Taylor 2021) or months (Bacon *et al.* 2022), that these two sign types are functionally equivalent (Bacon *et al.* 2022, 3), or that their meanings remained unchanged for tens of thousands of years (Bacon *et al.* 2022, 3). Ethnographically, dots in rock art



**Figure 2.** Taylor's (2021) identification of 'fogged hot breath' of the stag from Lascaux (France) to support the supposition that it is in a 'rutting condition' and calling to females is actually just the natural colour of the rock. (Photograph: J. Vertut, P. Bahn collection.)

have multiple meanings, for example, bees, seeds, stars, raindrops, huts, fires, tracks or blood, and a set of three dots can evoke the stones of the hearth as well as the hunter, his dog and the game (Delano Smith 1982, 20; Faik-Nzujj 1998, 21; Lawson 2012, 221; Lewis-Williams 1995, 9; Maggs 1998, 20; Mveng 1964, 95; Patterson & Duncan 2014, 146–7; Solomon 2017) while 'arranging tiny dots in an orderly fashion around the body of bigger animals, ... appears to imply the nomadic people's hope of high animal reproduction' (Zhang 2014, 90). It is impossible to guess their meaning by observation alone without any other information. Furthermore, a single motif may have layers of meaning with each layer apparent according to the status of the viewer. Thus the meaning of a motif can change within an individual's lifetime (Calder *et al.* 1981; West 1988).

Archaeologically, dots and lines are some of the most common sign types in European Upper Palaeolithic art. For example, researchers have suggested that when dots are arranged in columns and rows they functioned as tally marks (d'Errico 1995; Marshack 1991) or may indicate zones of superior acoustic resonance (Reznikoff 2006, 79–80); when associated with animals they have been described as indicating hunting wounds (Baffier 1990; Breuil 1952; d'Huy & Le Quellec 2010; Delluc & Delluc 1989;

Lejeune 2000; Ucko & Rosenfeld 1967) and when found at the ends of galleries or at junction points in passageways, they may have acted as wayfinders or be signalling the limits of the decorated areas of the cave (Breuil 1952; Casado Lopez 1977; Leroi-Gourhan 1968; Ucko & Rosenfeld 1967). Other possible explanations for dots include that they are entoptic images produced during trance (Lewis-Williams 2002, but see Bahn 2001), that they represent constellations (Pásztor & Priskin 2010, but see above) or were created unintentionally through contact between cave walls and ochred bodies (Medina-Alcaide *et al.* 2018). Given that dots in European Palaeolithic art span 30,000 years and are found throughout the continent, it is likely that they had multiple meanings that shifted over time and space. Similarly, lines in association with animal or human figures have been interpreted as spears or the 'the pricking sensations of trance ... [hallucinated as] ... multiple stabbings of sharp pointed lances' (Lewis-Williams 1997, 826; see also Lorblanchet 2010; Solomon 2017).

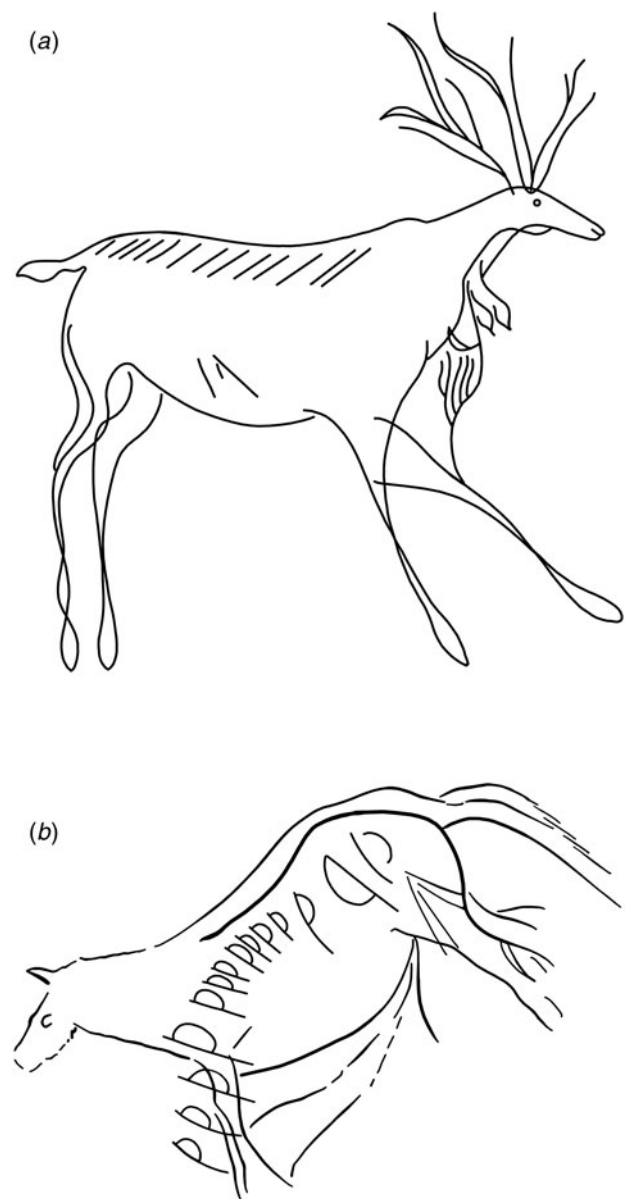
Turning to the Y-sign, there is no evidence to support the argument that it represents birth (i.e. parted legs or 'two becoming one') particularly when the sign is said to be in association with quadrupeds and fish—the latter not only do not have two legs but they lay hundreds or even thousands of eggs at a time depending on the species. Similarly, there is no basis for Taylor's (2021) interpretation of 'boxes' representing the full moon or a new moon. The reasoning offered is that they are easy to paint and reminiscent of the Chinese character for moon, but these observations are irrelevant.

A related issue is pareidolia (the human tendency to see order or a meaningful shape in a random or ambiguous visual pattern) or perhaps even more simply the human desire to see what one wants to see in an image. For example, Taylor (2021, 216, fig. 1) points to the 'fogged hot breath' of the stag from Lascaux to support the supposition that it is in a 'rutting condition' and calling to females, but what Taylor is interpreting as fogged breath is actually just the natural colour of the wall (Fig. 2). Taylor (2021) also frequently refers to 'pregnant animals' but as Bahn (2016, 294, 386) notes, 'The last resort of those seeking evidence of an interest in animal fertility was to see many figures, especially horses, as "pregnant". Yet even veterinarians cannot tell if a horse is pregnant from its profile alone (though they can do so from a back-view – J.R.B. Speed, Vet.M.B., M.R.C.V.S., pers. comm.)'. Quite apart from possible stylistic conventions involved in giving horses large, rounded bellies (as well as short legs, tiny heads, etc.), inflated stomachs can also be

the result of eating quantities of wet grass. If Taylor's (2021) assessment of horses as pregnant is correct (and this designation is crucial for his argument related to seasonality), then similarly drawn horses with phalluses would also have to be described as pregnant (Baffier 1984, 148–9; Bandi 1968, 16; Leroi-Gourhan 1966, 39; 1971, 89, 98). González Sainz and Ruiz Idarraga (2010, 69) likewise argue that pregnancy in horses based on images of them is simply not demonstrable, and Delluc (2006, 235) has pointed out that, at Lascaux, the big, explicitly sexed bulls have voluminous bellies 'like pregnant females' (Bahn 2016, 294, 386). Other examples of unwarranted interpretation include Taylor's (2021, 216, fig. 2) moon 'boxes' on the belly on the stag from Lascaux (Fig. 3a) and on the flank of a horse from Les Trois Frères cave (France) (Taylor 2021, 217, fig. 3) (Fig. 3b) and his (2021, 226, fig. 12) insistence that he can see 'the cow's vagina and cervix which in this image is open to the birth canal' on the jumping cow from Lascaux (Fig. 4) (which Taylor has renamed the 'birthing auroch').

#### Source criticism

Archaeologists often base their interpretations on reproductions of Palaeolithic parietal images (tracings, drawings, photographs and digital imagery), particularly when images are difficult to access, require special technology to view, or have faded with time. Depending on the technology used and the goal of the individual creating the reproductions, the results can vary greatly. For example, lack of first-hand knowledge of the images combined with the uneven quality of the reproductions used undermines the accuracy of Taylor's (2021) and Bacon *et al.*'s (2022) findings (see discussion in García-Bustos *et al.* 2023). In some cases, the authors rely on lines that appear in the drawings but do not exist in the original paintings or engravings. For example, *contra* Bacon *et al.* (2022, fig. 2c), the horse from Sotarriza (Spain) has no lines under it or around it. Both a photograph and an accurate drawing of the animal (González Sainz & San Miguel Llamosas 2001, 212, 134) demonstrate that it is nothing more than a simple outline of a black horse (Fig. 5). Similarly, Bacon *et al.* (2022; fig. 2e), point to a Y-sign on the Commarque horse (France), based on a sketch by Delluc and Delluc (1981). However, both a photograph and an analytical tracing found in the same article by the Dellucs (1981) show that no such Y-sign exists (Fig. 6). This is further corroborated by Breuil's (1952) drawing of the animal. Another example is Bacon *et al.*'s (2022, fig. 2a) use of the Pair-non-Pair horse (France) to

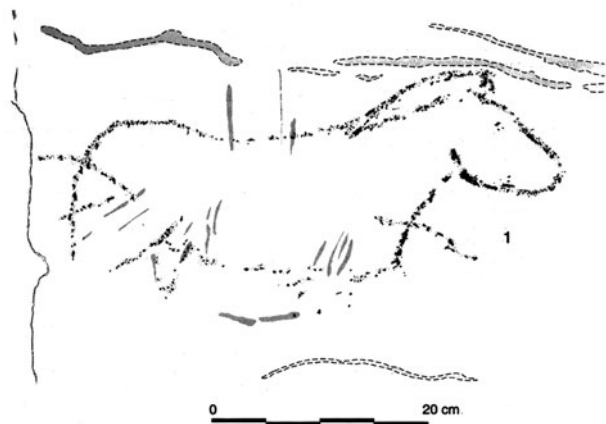


**Figure 3.** (a) Moon 'boxes' on the belly of the stag from Lascaux and (b) on the flank of a horse from Les Trois Frères cave (France) are more obviously described as lines and claviforms, respectively. (After Ruspoli 1987, 156.)

support their arguments. They rely on a sketch of the horse made in 1896 by Daleau, who unfortunately had no experience or expertise in copying cave engravings and who had not yet cleaned sediment off the walls. The lines shown touching the leg do not exist (Lenoir *et al.* 2013, 15). A final example is the engraved horse on a plaquette (thin stone slab) from Parpalló (Spain) (Bacon *et al.* 2022; fig. 2f). It is in association with a V-shaped sign and not a Y-sign (Villaverde Bonilla 1994, fig. 180) (Fig. 7).



**Figure 4.** Taylor (2021) identifies the cow's vagina and cervix which he describes as open to the birth canal on the jumping cow from Lascaux, but these features are not apparent in photographs. (Photograph: J. Vertut, P. Bahn collection.)



**Figure 5.** The simple outline in black of a horse from Sotarriza (Spain). (After González Sainz & San Miguel Llamosas 2002.)

In other cases, older reproductions may not be drawn to scale; and this is relevant because it calls into question whether the lines, dots and Y-signs identified by Taylor (2021) and Bacon and colleagues (2022) are actually in association with a particular animal. For example, Bacon *et al.* (2022, fig. 1h) rely on Breuil's (Alcalde del Río *et al.* 1911, 61) drawing of the Pindal mammoth (Fig. 8), but it gives no sense of the distance between the animal and the lines. In reality, one set of lines is 60 cm to the left of the animal while another set is 160 cm away

from it. This latter grouping is far more likely to mark the end of the cave's decoration, as is the case at the other end of the Pindal frieze and in other caves (González-Pumariiega Solis 2011) than to be communicating calendrical information related to the mammoth.

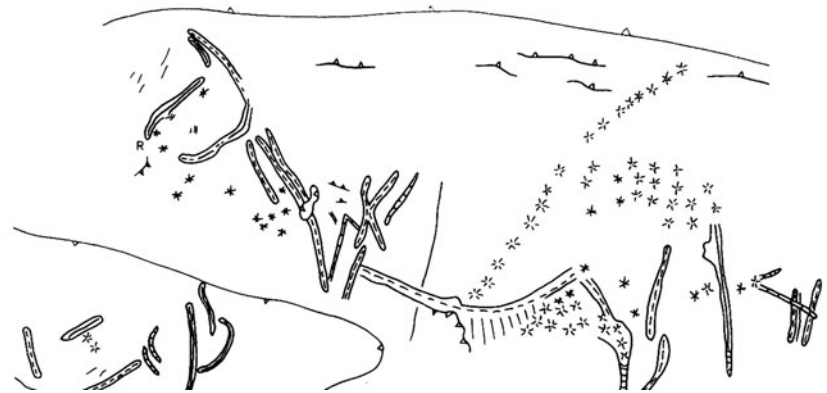
This raises an important issue: even in cases where the animals are in close proximity to the non-figurative signs, how can archaeologists discern association (i.e. a meaningful relationship) from juxtaposition (a coincidental relationship)? Related to this, another source of error is not being aware of the sequence in which the images were produced—again, something that may not be apparent from reproductions or that may be erroneously indicated in them. For example, *contra* Bacon *et al.* (2022, fig. 1e), the red dots on the Lascaux stag frieze (Fig. 9) were created before the stags, and are far more likely to be linked—if they are linked to anything—to the red horse head above them (Aujoulat 2005) than to the stag. Similarly, the Pindal fish (Bacon *et al.* 2022, fig. 1f) was engraved *after* the 3 red dots supposedly associated with it, with an unknown temporal interval in between (González-Pumariiega Solis 2011). Furthermore, there are 4 dots to the right of the fish, and an additional 19 dots just above this group of 4, and another 4 dots above the fish (González-Pumariiega Solis 2011), rendering the association between the fish and dots ambiguous at best (Fig. 10).

Finally, another limitation of interpretations based on published data is lack of appreciation of other salient aspects of the location—for example, the difficulty of reaching the place where art is made (see below). This observation underlines the basic fact that looking through books and papers for examples is no substitute for looking at the original images in the caves and seeing precisely where the images are drawn.

#### *The use of ethnographic analogy*

As Nowell and French (2020, 17) observe, 'Recent hunter-gatherers are not direct and unproblematic analogues for Palaeolithic hunter-gatherers. Nonetheless, both past and prehistoric forager societies share many demographic similarities, including small group size, low population density and high mortality.' The relationship between demography and key features of foraging ways of life makes modern hunter-gatherers a reasonable source of information for generating hypotheses about the lives of modern humans living in the Upper Palaeolithic and for providing checks and balances on interpretations created by archaeologists whose knowledge and experiences

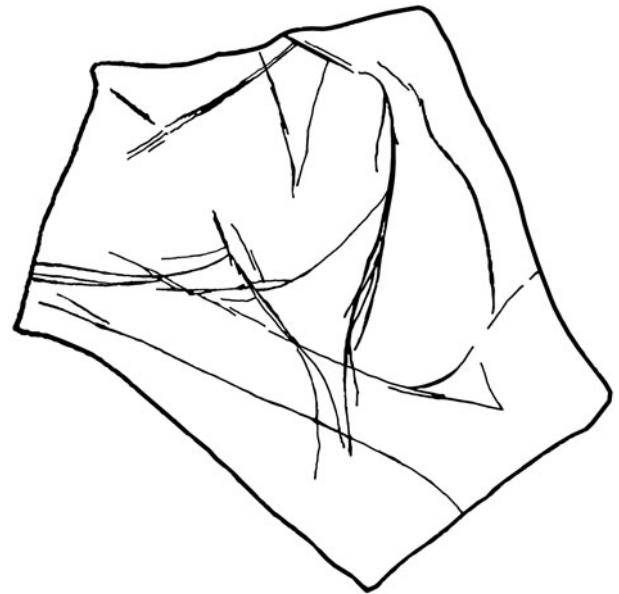
**Figure 6.** Contra Bacon et al. (2022), a photograph and drawing of the Commarque horse (France) show no Y-sign associated with the animal. (Analytical tracing, after Delluc & Delluc 1981.)



may be completely different from the societies they are studying. The use of ethnographic analogy by the proponents of the lunar calendar interpretation is uneven—Taylor (2021) draws on a mix of foraging and pastoralist societies with the latter being less appropriate models, while Bacon *et al.* (2022) do not appear to have consulted the ethnographic literature at all.

In 2011, Hayden and Villeneuve published a paper that explored the ethnographic evidence for astronomical knowledge among hunter-gatherers. They surveyed 82 hunter-gatherer cultures that they divided into ‘simple’ (n=7) and ‘complex’ (n=75). According to these researchers (Hayden & Villeneuve 2011, 335), complex hunter-gatherers are characterized by relatively high population densities (0.2–10.0 people/sq. km), seasonal or full sedentism, individual or family control of products and significant socio-economic differences within communities often reflected in burials, trade and the creation of prestige objects based on surpluses, and elaborate feasting activities based on surpluses, and complex counting systems. By contrast simple, more egalitarian hunter-gatherers are characterized by ‘communally owned resources, simple counting systems limited to 10–20 numbers, minimal socioeconomic inequalities or prestige objects and negligible economically- based competition or feasting or marriage payments’ (Hayden & Villeneuve 2011, 335). They argue, based on archaeological evidence, that Upper Palaeolithic groups situated ‘in the most productive Eurasian environments were complex hunter-gatherers’ (Hayden & Villeneuve 2011, 335, emphasis in the original). These environments include the Dordogne (France) and Cantabrian Spain, from where many of the images used to support the Lunar Calendar interpretation are derived.

Hayden and Villeneuve (2011, 340) discovered that 84 per cent (63/75) of complex hunter-gatherers



**Figure 7.** Contra Bacon et al. (2022), the engraved horse on a plaquette from Parpallo (Spain) (Bacon et al. 2022, fig. 2f) is in association with a V-shaped sign and not a Y-sign (Villaverde Bonilla 1994, 180). (After Villaverde Bonilla 1994.)

‘exhibited some solstice observation or monitoring and/or calendars (most often lunar).’<sup>2</sup> Importantly, these observations correlated with setting the correct date for ceremonies, rituals and feasts, particularly when many families would have to coordinate and pool resources. These ceremonies typically involved more than preparing food, but also complex webs of social and material debt. In sum, ‘What emerges from these observations . . . is a pattern among complex hunter-gatherers of solstice-monitoring systems together with varying developments of calendrical systems based on lunar cycles and days leading up



**Figure 8.** In Breuil's (Alcalde del Río *et al.* 1911, 61) drawing of the Pindal mammoth, the distance between the animals and the sets of lines is not drawn to scale, giving the false impression that they are in association with each other. In reality, one set of lines is 60 cm away from the mammoth while the other set is 160 cm away and not even visible on this photo of the mammoth. (Photograph: P. Bahn.)



**Figure 9.** The red dots on the Lascaux stag frieze were painted before the animal figure and are far more likely to be linked to the red horse head above them (Aujoulat 2005) than to the stag. (Photograph: J. Vertut, P. Bahn collection).

to key solar events such as solstices' that are tied to important ceremonies and rituals (Hayden & Villeneuve 2011, 340) rather than mating, birthing and seasonal migrations. Hayden and Villeneuve's work highlights the importance of choosing appropriate ethnographic analogies from which to formulate hypotheses and test implications—the more points of connection between known variables (e.g. level of socio-economic complexity), the stronger the case is for analogical reasoning.

## Implications of the Lunar Calendar interpretation

### *The calendar's heuristic value*

If, as Bacon *et al.* (2022) assert, the Y-sign truly does symbolize the verb 'to give birth', i.e. the birthing season, it begs the question of the heuristic value of the lunar calendar. All herbivore prey species they study give birth one to two months following the start of spring or the 'bonne saison'. Thus, since all these species are the same, there is no information content there to coordinate or of which to keep track. Bacon *et al.* (2022, 6) dismiss other possible reasons for tally marks, stating 'It seems to us unnecessary to need to convey information about the numbers of individual animals, the times they have been sighted, or the number of successful kills'. But why would Palaeolithic people need a calendar to record or predict the mundane fact that all their major herbivores give birth one or two months after the snow melts? If they use the temperature and the visual cue of snow melting to know when to start their calendar (Bacon *et al.* 2022, 7), it is likely they can deduce when birthing will take place without one.

Further undermining the lunar calendar interpretation is the location of the art. Why place practical information such as the birthing season of bison in the deepest reaches of caves, in often the hardest places to get to, with low visibility? In the above-mentioned case of the Sotarriza horse image, the artist literally risked life and limb to reach the place where the drawing was made. As Magli (2023, 4) writes,

**Figure 10.** The Pindal fish was engraved after the three red dots with an unknown temporal interval in between. The four dots to the right of the fish, and the additional 19 dots just above this group of four, and another four dots above the fish (González-Pumariiega 2011) make the associations between the fish and dots ambiguous. In the photo, the fish and three dots are at centre left (Photograph: P. Bahn.)



why was it felt necessary to convey such ‘calendrical’ information? Information on mating, migration and the like was of course very well known to all hunter-gatherers and was certainly contained in their cultural background since childhood, making it unlikely the idea that it was necessary to go into a dark cave to see the dots/bars – say, on an auroch’s image in order to know the time of their mating. Actually, it seems to the present author that instead of giving credit to the Palaeolithic mind the idea that this ‘proto-writing system’ was used by hunter-gatherers for some 25000 years to write always the same information does not render justice to their way of knowing and connecting with nature.

#### *Lunar calendars and implications for the origins of writing*

Bacon *et al.* (2022, 1) claim that the results of their study ‘[give] us our first specific reading of European Upper Palaeolithic communication, the first known writing in the history of *Homo sapiens*’. They (2022, 14, 15) also claim that the signs ‘functioned as words’ and that the Y-sign ‘may be the first known example of an “action” word, i.e. a verb (“to give birth”), although we acknowledge that this is ambiguous: it could function as a noun, “birth”, or “place of birth”’. They then write that ‘We will presumably never know the specific words for [animals, moon phases, the *bonne saison*, mating and birthing] in whatever languages were spoken in Upper Palaeolithic Europe, but we can assume that our script could be communicated orally by using them. Is this then, not the definition of writing?’.

The simple answer is no, this is not ‘writing’. Writing is a system of intercommunication based on the use of conventional visible marks produced on a durable surface whereby all parts of a language are represented (nouns, pronouns, verbs, etc.) (Coulmas 1996; Gelb 1963; Trigger 2004; Von Petzinger 2017). Furthermore, writing is a symbol-based system where there is an agreed-upon relationship between an arbitrary sign and its referent. With the development of writing linked to the rise of sedentary, high-density, hierarchical, urbanized societies, it is unlikely that there are many symbols within the category of non-figurative signs in Upper Palaeolithic art (Schmandt-Besserat 1992; Von Petzinger 2017 and references therein).

Bacon *et al.* (2022, 14) also write, ‘We have proposed the existence of a notational system associated with an unambiguous animal subject, relating to biologically significant events informed by the ethological record, which allows us for the first time to understand a Palaeolithic notational system in its entirety.’ Even if we take this at face value, there is no agreed upon typology of Palaeolithic signs (Le Quellec 2022, 323–36; see also Tauxe 2007), and inventories sometimes mention at least 32 different sign types (Von Petzinger 2017), 42 types (Casado López 1977) or even 52 types (Vialou 1986), leaving at least 90 per cent of the notational system unknown.

The larger issue here is that Bacon and colleagues (2022) have not designed their study in such a way as to allow them to decipher a system of writing. In deciphering a written language, linguists

follow tried and tested procedures. They rely on the fact that a written language (like a spoken language) has redundancy built into it—certain combinations of signs occur more frequently than others. As Gelb (1975) notes, ‘most of the methods of decipherment make use of this fact, and the degree of difficulty or ease with which a writing system can be deciphered depends in large measure on the extent to which this feature can be recognized and exploited’. Gelb (1975, 96) distinguishes four categories of decipherment that become progressively challenging (if not impossible): Type 0 (Known Writing and Known Language); Type I (Unknown Writing and Known Language); Type II (Known Writing and Unknown Language); and Type III (Unknown Writing and Unknown Language). If the non-figurative signs of Palaeolithic art were writing, they would certainly be Type III. In all cases, decipherment requires deep knowledge of the historical-geographical background of the people who created the ‘script’, of grammatology (the structure and typology of writing that can allow one to answer the basic question of whether something is writing or not) and graphotactics (the evaluation of the position, sequences, arrangement and direction of signs and word division). It would also require the ‘systematic application of statistics to determine redundancy characteristics of the writing’ (Gelb 1975, 102). None of these methods were employed by Bacon *et al.* (2022).

Bacon *et al.* specifically refer to the signs as ‘writing’ in their abstract (2022, 1) and conclusion (2022, 15) but they use the term ‘proto-writing’ in their title. In their final paragraph, they conclude (2022, 15), ‘We do not want to press the controversial (and in many senses, semantic) question of whether writing was a Palaeolithic invention; perhaps it is best described as a proto-writing system, an intermediary step between a simpler notation/convention and full-blown writing’. When someone says, ‘it is just semantics’, what they mean is that the difference in meaning is trivial, that it is negligible, except in this case, writing and proto-writing are two very different systems of communication that require different analytical methods and approaches to decipherment and have different cognitive, social and cultural implications. With proto-writing, artificially created graphic marks are used to record and transmit information, but unlike with writing there is no direct relationship to a spoken language and cultural knowledge is needed to fill in the missing components (see, for example, Born 2023 and references therein for a detailed discussion of appropriate methods for the

decipherment of proto-Elamite). At the end of the day, Bacon *et al.* (2022) have not demonstrated the existence of either writing or proto-writing. They have merely shown that sequences of 3 and 4 motifs are the most common; whether this means birth month, number of animals the artist saw, something else, many things all at once or nothing at all remains entirely unknown.

## Conclusion

In this paper, we reviewed variations of the Lunar Calendar interpretation of Upper Palaeolithic rock art, focusing on recent publications by Taylor (2021) and Bacon *et al.* (2022). Although some assumptions (e.g. the degree of hunter-gatherer dependence on game animals, the necessity of a calendar to predict when herbivores give birth) are questionable, the key issue is that the interpretations as presented are not testable. In the case of Bacon *et al.* (2022), because they have not formulated a hypothesis with concomitant test implications, their statistical results do nothing more than confirm what archaeologists have long recognized—that short sequences of non-figurative signs are most common. As Magli (2023) observed, their results can be used to answer many different questions with no way to judge between them—it is correlation without causation. Other concerns common to all proponents of this interpretation are a disregard of the scientific method, unsupported assumptions and a selective use of data, a reliance on secondary sources and an uneven use of appropriate ethnographic analogies. The arbitrary choice of the purported meanings of the signs and figurative images, the irrelevance of the message to be transmitted (e.g. ‘giving birth’), the inaccessibility of ‘key’ information (e.g. Sotarriza Cave), the use of unlikely premises as facts/foundations of the Lunar Calendar ‘hypothesis’ and the lack of evidence for (proto)writing are further weaknesses of these proposed explanations of Upper Palaeolithic art.

As is often the case in archaeology, context is everything. These studies highlight the importance of an in-depth knowledge of both the parietal art and the cultures in which it was produced. They also underscore the necessity of applying the scientific method—of the careful construction of hypotheses and choice of appropriate methods for data collection and analysis. Unsubstantiated claims do nothing to move our field closer to understanding why people millennia ago chose to enter caves to create art—in fact, they move us further away.

## Notes

1. In French, the phrase is 'belle saison'.
2. Hayden and Villeneuve (2011) argue that, given the near ubiquity of this behaviour across regions and language groups, it is possible that some early ethnographers did not record or did not have access to this cultural knowledge.

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## References

- Alcalde del Río, H., H. Breuil & L. Sierra, 1911. *Les Cavernes de la Région Cantabrique* [Caves of the Cantabrian Region]. Monaco: Imprimerie Chêne.
- Antequera Congregado, L., 1991. *Arte y astronomía. Evolución de los dibujos de las constelaciones* [Art and Astronomy. Evolution of Constellation Drawings]. Doctoral dissertation, Universidad Complutense de Madrid.
- Aujoulat, N., 2005. *Glory of Lascaux: Rediscovering the great treasure of prehistoric art*. London: Thames & Hudson.
- Averbouh, A. & V. Feruglio, 2016. L'ancrage du symbolique dans le réel. Réflexions sur les représentations de bois de cerfs à Lascaux (Dordogne, France) [The anchoring of the symbolic in reality. Reflections on the representations of deer antlers in Lascaux (Dordogne, France)]. *Paleo: Hommage à Norbert Aujoulat* (numéro hors série), 91–102.
- Azéma, M., 2006. La représentation du mouvement au Paléolithique supérieur: Apport du comparatisme ethnographique à l'interprétation de l'art pariétal [The representation of movement in the Upper Palaeolithic: the contribution of ethnographic analogy to the interpretation of parietal art]. *Bulletin de la Société préhistorique française* 103(3), 479–505.
- Bacon, B., A. Khatiri, J. Palmer, T. Freeth, P. Pettitt & R. Kentridge, 2022. An Upper Palaeolithic proto-writing system and phenological calendar. *Cambridge Archaeological Journal* 33(3), 371–89.
- Baffier, D., 1984. Les caractères sexuels secondaires des mammifères dans l'art pariétal paléolithique franco-cantabrique [Secondary sexual characteristics of mammals in Franco-Cantabrian Palaeolithic parietal art ], in *La Contribution de la Zoologie et de l'Ethologie à L'interprétation de L'art des Peuples Chasseurs Préhistoriques*, ed. H.-G. Bandi. Fribourg: Editions Universitaires, 143–54.
- Baffier, D., 1990. Lecture technologique des représentations paléolithiques liées à la chasse et au gibier [A technological reading of Paleolithic representations linked to hunting and game]. *Paléo* 2, 177–90.
- Bahn, P.G., 2001. Save the last trance for me: an assessment of the misuse of shamanism in rock art studies, in *The Concept of Shamanism: Uses and abuses*, eds H.P. Francfort & R.N. Hamayon. Budapest: Akadémiai Kiadó, 51–93.
- Bahn, P.G., 2016. *Images of the Ice Age*. Oxford: Oxford University Press.
- Bandi, H.-G., 1968. Art quaternaire et zoologie [Quaternary art and zoology], in *Simposio de Arte Rupestre, Barcelona 1966*, ed. E. Ripoll Perelló. Barcelona: Diputació Provincial de Barcelona, Instituto de Prehistoria y Arqueología, 13–19.
- Born, L.O., 2023. *Applications of Natural Language Processing to Archaeological Decipherment: A Survey of Proto-Elamite*. Doctoral dissertation, Simon Fraser University.
- Bourdier, F., 1968. Préhistoire des religions [Prehistory of religion]. *Raison présente* 3, 97–105.
- Bouvier, J.-M. & C. Dubourg, 1997. Karst et saisonnalités paléolithiques [Karst and Paleolithic seasonality]. *Quaternaire* 8 (2-3), 233–44.
- Breuil, H., 1952. *Four Hundred Centuries of Cave Art*. Montignac: Centre d'Etudes et de Documentation Préhistoriques.
- Calder, D., A. Crocker, R. Ridgeway, Papunya Tula Artists Pty. Ltd & Aboriginal Artists Agency, 1981. *Mr Sandman Bring Me a Dream* [compiled by Andrew Crocker]. Alice Springs: Aboriginal Artists Agency with Papunya Tula Artists Pty. Ltd.
- Casado López, M. del P., 1977. *Los Signos en el Arte Paleolítico de la Península Ibérica* [Signs in Paleolithic art of the Iberian peninsula]. Zaragoza: Departamento de Prehistoria y Arqueología de la Facultad de Filosofía y Letras.
- Conkey, M., 1997. Beyond art and between the caves: thinking about context in the interpretive process, in *Beyond Art: Pleistocene image and symbol*, eds M.W. Conkey, O. Soffer, D. Stratmann & N.G. Jablonski. (Wattis Symposium series in anthropology 23.) San Francisco (CA): California Academy of Sciences, 343–68.
- Coulmas, F. (ed.), 1996. *The Blackwell Encyclopedia of Writing Systems*. Oxford: Blackwell.
- d'Errico, F., 1995. A new model and its implications for the origins of writing: the La Marche antler revisited. *Cambridge Archaeological Journal* 5(2), 163–206.

- d'Errico, F., 2002. Memories out of mind: the archaeology of the oldest artificial memory systems, in *In the Mind's Eye: Multidisciplinary approaches to the evolution of human cognition*, ed. A. Nowell. (International Monographs in Prehistory 13.) Ann Arbor (MI): Berghahn Books, 33–49.
- Dehaene, S., 2024. La perception des objets mathématiques élémentaires (1): formes géométriques, motifs et graphes [The perception of elementary mathematical objects: geometric forms, motifs and graphs]. Paper presented at the Collège de France, 26 January 2024. [https://www.youtube.com/watch?v=k\\_ykA1S2\\_o](https://www.youtube.com/watch?v=k_ykA1S2_o)
- d'Huy, J. & J.-L. Le Quellec, 2010. Les animaux 'fléchés' à Lascaux: nouvelle proposition d'interprétation [The 'arrowed' animals at Lascaux: new proposed interpretation]. *Préhistoire du Sud-Ouest, Association Préhistoire quercinoise et du Sud-Ouest* 18(2), 161–70.
- Delano Smith, C., 1982. The emergence of 'maps' in European rock art: a prehistoric preoccupation with place. *Imago Mundi: The International Journal for the History of Cartography* 34(1), 9–25.
- Delluc, B. & G. Delluc, 1981. La grotte ornée de Comarque à Sireuil (Dordogne) [The decorated cave of Comarque in Sireuil (Dordogne)]. *Gallia Préhistoire* 24, 1–97.
- Delluc, B. & G. Delluc, 1989. Le sang, la souffrance et la mort dans l'art paléolithique [Blood, suffering and death in Paleolithic art]. *L'Anthropologie* 93(2), 389–406.
- Delluc, B. & G. Delluc, 2004. À propos des dessins de mammoths archaïques en Dordogne [On the drawings of archaic mammoths in the Dordogne]. *Bulletin de la Société Historique et Archéologique du Périgord* 131, 103–22.
- Delluc, G., 2006. *Le Sexe au Temps des Cro-Magnons* [Sex in the time of Cro-Magnons]. Périgueux: Edition Pilote 24.
- Dequerlor, C., 1975. *Les oiseaux messagers des dieux* [Bird messengers of the gods]. Paris: Albin Michel.
- Ducasse, S. & M. Langlais, 2019. Twenty years on, a new date with Lascaux. Reassessing the chronology of the cave's Paleolithic occupations through new 14C AMS dating. *Paleo* 30(1), 130–47.
- Edge, F., 1995. Taurus in Lascaux. *Griffith Observer* 61, 13–17.
- Edge, F., 1997. Aurochs in the sky: dancing with the summer moon. A celestial interpretation of the Hall of Bulls from the cave of Lascaux. *Memoria della Società Astronomica Italiana* 68, 35–8.
- Faïk-Nzuji, C., 1998. *Le Dit des signes. Répertoire de symboles graphiques dans les cultures et les arts africains* [The tale of signs: a repertoire of graphic symbols in African cultures and arts]. Paris: Maisonneuve & Larose.
- Gaffney, V., S. Fitch, E. Ramsey, et al., 2013. Time and a place: a luni-solar 'time-reckoner' from 8th millennium BC Scotland. *Internet Archaeology* 34. <https://doi.org/10.11141/ia.34.1>
- García-Bustos, M., Rivero, O., Sauvet, G. & García-Bustos, P., 2023. Discussion: 'An Upper Palaeolithic Proto-writing System and Phenological Calendar' by Bennett Bacon et al. *Journal of Paleolithic Archaeology* 6(1), 32.
- Gelb, I., 1963. *A Study of Writing*. Chicago (IL): University of Chicago Press.
- Gelb, I.J., 1975. Methods of decipherment. *Journal of the Royal Asiatic Society* 107(2), 95–104.
- González-Pumariega Solís, M., 2011. *La Cueva de El Pindal 1911–2011* [El Pindal Cave 1911–2011]. Pola de Siero: Ediciones Ménsula.
- González Sainz, C. & R. Ruiz Idarraga, 2010. *Una Nueva Visita a Santimamiñe. Precisiones en el conocimiento del conjunto parietal paleolítico* [Santimamiñe revisited. Precisions in the knowledge of its Palaeolithic parietal art]. (KOBIE 11.) Bilbao: Bizkaiko Foru Aldundia.
- González Sainz, C. & C. San Miguel Llamosas, 2001. *Las Cuevas del Desfiladero. Arte rupestre paleolítico en el valle del río Carranza (Cantabria-Vizcaya)* [The gorge caves. Paleolithic rock art in the Carranza river valley (Cantabria-Vizcaya)]. Santander: Servicio de Publicaciones de la Universidad de Cantabria.
- Hayden, B. & S. Villeneuve, 2011. Astronomy in the Upper Palaeolithic? *Cambridge Archaeological Journal* 21(3), 331–55.
- Huffer, C.M., F.E. Trinklein & M. Bunge, 1967. *An Introduction to Astronomy*. New York (NY): Holt, Rinehart & Winston.
- Jègues-Wolkiewiez, C., 2011. *Sur les chemins étoilés de Lascaux* [On the starry paths of Lascaux]. Hyères: La Pierre philosophale.
- Jègues-Wolkiewiez, C., 2014. *Le calendrier solaire paléolithique de Sergeac décodé* [The Palaeolithic solar calendar of Sergeac decoded]. Bouches-du-Rhône: Groupe CCEE.
- Lawson, A.J., 2012. *Painted Caves: Palaeolithic rock art in Western Europe*. Oxford: Oxford University Press.
- Le Quellec J.-L., 2022. *La Caverne Originelle. Art, mythes et premières humanités* [The original cave. Art, myths, and early humans]. Paris: Editions La Découverte.
- Lejeune, M., 2000. La chasse dans l'art préhistorique [Hunting in prehistoric art]. *Anthropologie et Préhistoire* 111, 410–15.
- Lenoir, M. A. Roussot, B. Delluc, et al., 2013. *La Grotte de Pair-non-Pair* [Pair-non-pair Cave] (2nd edn). Bordeaux: Société Archéologique de Bordeaux.
- Leroi-Gourhan, A., 1966. Réflexions de méthode sur l'art paléolithique [Reflections on methods of Palaeolithic art]. *Bulletin Société Préhistorique française* 63, 35–49.
- Leroi-Gourhan, A., 1968. *The Art of Prehistoric Man in Western Europe*. London: Thames & Hudson.
- Leroi-Gourhan, A., 1971. *Préhistoire de l'Art Occidental* [Prehistory of Occidental art] (2nd edn). Paris: Mazenod.
- Lewis-Williams, D., 1995. Seeing and construing: the making and 'meaning' of a southern African rock art motif. *Cambridge Archaeological Journal*, 5(1), 3–23.
- Lewis-Williams, D., 1997. Agency, art and altered consciousness: a motif in French (Quercy) Upper Paleolithic parietal art. *Antiquity* 71, 810–30.

- Lewis-Williams, D., 2002. *The Mind in the Cave: Consciousness and the origins of art*. London: Thames & Hudson.
- Lorblanchet, M., 2007. À la recherche de l'art pariétal aurignacien du Quercy [In search of Aurignacian parietal art in Quercy], in *Les Chemins de l'art aurignacien en Europe* [Paths of Aurignacian art in Europe], eds H. Floss, N. Rouquerol & L. Barbot. (Cahier 4.) Aurignac: Éditions Musée-Forum Aurignac, 187–208.
- Lorblanchet, M., 2010. *Art Pariétal: Grottes ornées du Quercy* [Parietal art: the decorated caves of Quercy]. Paris: Rouergue.
- Maggs, T., 1998. Cartographic content of rock art in Southern Africa, in *The History of Cartography 2.3: Cartography in the Traditional African, American, Arctic, Australian, and Pacific Societies*, eds D. Woodward & G.M. Lewis. Chicago (IL): University of Chicago Press, 13–23.
- Magli, G., 2023. *Statistics in the Study of Palaeolithic Art: The case of the alleged 'phenological calendar'* (1 March). Available at SSRN: <https://ssrn.com/abstract=4395377> or <http://dx.doi.org/10.2139/ssrn.4395377>
- Marshack, A., 1972. *The Roots of Civilization*. Chicago (IL): McGraw-Hill.
- Marshack, A., 1991. *The Roots of Civilization* (2nd edn). Mt Kisco (NY): Moyer Bell.
- Medina-Alcaide, M.A., D. Garate Maidagan & J.L. Sanchidrián Torti, 2018. Painted in red: in search of alternative explanations for European Palaeolithic cave art. *Quaternary International* 491, 65–77.
- Milton, K., 2000. Hunter-gatherer diets – a different perspective. *American Journal of Clinical Nutrition* 71(3), 665–7.
- Mithen, S.J., 1991. Ecological interpretations of Palaeolithic art. *Proceedings of the Prehistoric Society* 57(1), 103–14.
- Mveng, E., 1964. *L'Art d'Afrique Noire. Liturgie cosmique et langage religieux* [The art of Black Africa: cosmic liturgy and religious language]. Tours: Mame.
- Nowell, A., 2023. Oral storytelling and knowledge transmission in Upper Paleolithic children and adolescents. *Journal of Archaeological Method and Theory* 30(1), 9–31.
- Nowell, A. & J. French, 2020. Adolescence and innovation in the European Upper Palaeolithic. *Evolutionary Human Sciences* 2020(2), e36.
- Ollier de Marichard, J., 1868. Recherches sur l'ancienneté de l'homme dans les grottes des environs de Vallon (Ardèche) [Research on the antiquity of man in the caves around Vallon (Ardèche)]. *Bulletin de la Société des Sciences Naturelles et Historiques de l'Ardèche* 4, 87–108.
- Pásztor, E. & A. Priskin, 2010. *Celestial Symbols Revisited*. Palaeolithic Sky Lore: Fiction or Fact? Paper presented at the IFRAO Congress, September 2010, Symposium: Signs, Symbols, Myth, Ideology.
- Patterson, C. & C. Duncan, 2014. Concepts of spirit in prehistoric art according to Clifford Duncan, Ute Spiritual Elder, in *Rock Art and Sacred Landscapes*, eds D.L. Gillette, M. Greer, M.H. Hayward & W.B. Murray. New York (NY): Springer, 139–61.
- Pigeaud, R., 2000. L'image du cheval dans l'art quaternaire [The image of the horse in Quaternary art]. *Ethnozootechnie* 64, 3–28.
- Peyrony, D., 1932. Les abris Lartet et du Poisson à Gorge d'Enfer (Dordogne). II. Abri du Poisson [The Lartet and Poisson rock shelters in the Gorge d'Enfer (Dordogne). II. Poisson rock shelter]. *L'Anthropologie* 42, 245–68.
- Rappenglück, M.A., 1997. The Pleiades in the 'Salle de Taureaux', Grotte de Lascaux. Does a rock picture in the cave of Lascaux show the open star cluster of the Pleiades at the Magdalénien era (ca. 15.300 BC)?, in *Actas del IV Congreso de la SEAC 'Astronomia en la Cultura'/Proceedings of the 10th SEAC Meeting 'Astronomy in Culture'*, eds C. Jaschek & F. Atrio Barendela. Salamanca: Universidad de Salamanca, 217–25.
- Rappenglück, M.A., 1999. *Eine Himmelskarte aus der Eiszeit? Ein Beitrag zur Urgeschichte der Himmelskunde und zur paläoastronomischen Methodik, aufgezeigt am Beispiel der Szene in Le Puits, Grotte de Lascaux (Montignac, Dép. Dordogne, Rég. Aquitaine, France)* [A sky map from the Ice Age? A contribution to the prehistory of celestial science and paleoastronomical methodology, illustrated by the example of the scene in Le Puits, Grotte de Lascaux (Montignac, Dordogne department, Aquitaine region, France)]. Frankfurt: Peter Lang.
- Rappenglück, M.A., 2000. The whole cosmos is turning around the polar point: one-legged polar beings and their meaning, in *Astronomy and Cultural Diversity*, eds C. Esteban & J.A. Belmonte. Santa Cruz de Tenerife: Organismo autonomo de Museos y Centros, 169–75.
- Rappenglück, M.A., 2001. Palaeolithic timekeepers looking at the golden gate of the ecliptic; the lunar cycle and the Pleiades in the cave of La-Tête-du-Lion (Ardèche, France) – 21.000 BP. *Earth, Moon and Planets* 85–86, 391–404.
- Rappenglück, M.A., 2002. The Milky Way: its concept, function and meaning in ancient cultures, in *Proceedings of the Conference 'Astronomy of Ancient Civilizations'*, eds T.M. Potemkina & V.N. Obridko. Moscow: European Society for Astronomy in Culture (SEAC)/Joint European and National Astronomical Meeting (JENAM), 270–79.
- Rappenglück, M.A., 2004a. A Palaeolithic planetarium underground – the cave of Lascaux (Part 1). *Migration and Diffusion* 5(18), 93–119.
- Rappenglück, M.A., 2004b. A Palaeolithic planetarium underground – the cave of Lascaux (Part 2). *Migration and Diffusion* 5(19), 6–47.
- Rappenglück, M.A., 2009. Palaeolithic shamanistic cosmography: how is the famous rock picture of the shaft of the Lascaux grotto to be decoded? *Arte praehistorica*.

<http://www.artepreistorica.com/2009/12/palaeolithic-shamanistic-cosmography-how-is-the-famous-rock-picture-in-the-shaft-of-the-lascaux-grotto-to-be-decoded/> (consulted 28 April 2020).

- Rappenglück, M.A., 2014. Possible astronomical depictions in Franco-Cantabrian Paleolithic rock art, in *Handbook of Archaeoastronomy and Ethnoastronomy*, ed. C. Ruggles. New York (NY): Springer, 1205–12.
- Reznikoff, I., 2006. The evidence of the use of sound resonance from Palaeolithic to Medieval times, in *Archaeoacoustics*, eds C. Scarre & G. Lawson. Cambridge: McDonald Institute for Archaeological Research, 77–84.
- Ringer, Á., 2020. Decoding an Upper Palaeolithic system of symbols: Lascaux. *Praehistoria* 1–2(11–12), 253–301.
- Ringer, Á. & N. Németh, 2020. A new Upper Palaeolithic calendar type of Western Eurasia. *Praehistoria* 1–2(11–12), 239–251.
- Roussot, A., 1984. Peintures, gravures et sculptures de l'abri du Poisson aux Eyzies. Quelques nouvelles observations [Paintings, engravings, and sculptures from Poisson rock shelter in Eyzies. Some new observations]. *Préhistoire Ariégeoise Bulletin de la Société Préhistorique de l'Ariège Tarascon-sur-Ariège* 39, 11–26.
- Ruspoli, M., 1987. *Cave of Lascaux*. New York: Harry N. Abrams.
- Sauvet, G., 1994. Rhétorique de l'image préhistorique [Rhetoric in the prehistoric image], in *Psychanalyse et Préhistoire* [Psychoanalysis and prehistory], eds A. Fine, R. Perron & F. Sacco. Paris: PUF, 83–115.
- Schmandt-Besserat, D., 1992. *Before Writing*. Austin (TX): University of Texas Press.
- Solomon, A. 2017. Rock arts, shamans, and grand theories, in *The Oxford Handbook of the Archaeology and Anthropology of Rock Art*, eds B. David & I.J. McNiven. Oxford: Oxford University Press, 1–25.
- Tauxe, D., 2007. L'organisation symbolique du dispositif pariétal de la grotte de Lascaux [The symbolic organization of the parietal layout of Lascaux cave]. *Bulletin Préhistoire du Sud-Ouest* 15, 177–266.
- Taylor, B. 2021. Lunar timekeeping in Upper Paleolithic cave art. *Praehistoria*, n.s. 3(13), 215–32.
- Trick, L.M. & Z.W. Pylyshyn, 1994. Why are small and large numbers enumerated differently? A limited-capacity preattentive stage in vision. *Psychological Review* 101(1), 80–102.
- Trigger, B.G., 2004. Writing systems: a case study in cultural evolution, in *The First Writing: Script invention as history and process*, ed. S. Houston. Cambridge: Cambridge University Press, 39–68.
- Ucko, P.J. & A. Rosenfeld, 1967. *Paleolithic Cave Art*. New York (NY): World University Library.
- Vialou, D., 1986. *L'art des Grottes en Ariège Magdalénienne* [Cave art in Magdalenian Ariège]. Paris: CNRS.
- Villaverde Bonilla, V., 1994. *Arte Paleolítico de la Cova del Parpalló* [Palaeolithic art in the Cave of Parpalló]. Valencia: Servei d'Investigació Prehistòrica.
- Von Petzinger, G., 2017. *The First Signs: Unlocking the mysteries of the world's oldest symbols*. New York (NY): Simon & Schuster.
- Waring, G.H., 2007. *Horse Behavior. The behavioral traits and adaptations of domestic and wild horses, including ponies*. Norwich/New York: William Andrew Publishing.
- West, M.K.C. (ed.), 1988. *The Inspired Dream: Life as art in Aboriginal Australia*. South Brisbane: Museums and Art Galleries of the Northern Territory/Queensland Art Gallery.
- White Randall 2006. *L'Affaire de l'Abri du Poisson. Patrie et Préhistoire* [The Poisson rock shelter case. Patrimony and prehistory]. Périgueux: Fanlac.
- Zhang, Y. 2014. Spirituality and Chinese rock art, in *Rock Art and Sacred Landscapes*, eds D.L. Gillette, M. Greer, M.H. Hayward & W.B. Murray. New York (NY): Springer, 85–102.

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