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The role of materiality in numerical cognition

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ABSTRACT

Numerical elaboration and the extension of numbers to non-tangible domains such as time have been linked to cultural complexity in several studies. However, the reasons for this phenomenon remain insufficiently explored. In the present analysis, Material Engagement Theory, an emerging perspective in cognitive archaeology, provides a new perspective from which to reinterpret the cultural nexus in which quantification develops. These insights are then applied to representative Neolithic, Upper Palaeolithic, and Middle Stone Age artifacts used for quantification: clay tokens from Neolithic Mesopotamia, notched tallies from the European Upper Palaeolithic, hand stencils with possible finger-counting patterns as documented at Cosquer and Gargas, and stringed beads from Blombos Cave in South Africa.

1. Introduction

In 2011, Hayden and Villeneuve published an article that compared the astronomy practices of contemporary societies with artifacts and cave paintings thought to reflect possible practices of astronomy in the Upper Palaeolithic. I study numerical cognition, so my immediate reaction to their article was to ask, ‘How many numbers do you need to do astronomy?’ The answer turned out to be ‘very few’, since societies with limited counting sequences practiced astronomy nonetheless. However, one of the main reasons extant peoples practice astronomy is to tell time, and the availability of numbers changes how timekeeping is practiced. Before a system of numbers develops, time is estimated from natural phenomena. People use the height of the sun for the approximate time of day, the first occurrence of particular stars on the horizon for the approximate month, the temperature trend and other seasonal changes for the approximate time of year, and so on. But once numbers are available, time becomes quantified through practices like counting lunar appearances, and timekeeping by the quantification of time tends to displace the previous estimation techniques. Compare the number of people in any particular industrialized society, for example, who know how to estimate the month by the rising stars to the number of those who know how to obtain the information from some form of calendar. Likely the former will be negligible, the latter close to the number of those in the population, minus of course the infants and children too young to have learned their calendars.

The variables of cultural complexity, number system elaboration, and quantified timekeeping are predictably related, as demonstrated by two studies showing correlations between complexity in culture, complexity in number systems, and timekeeping behavior (Overmann, 2013a,b; a two-part 1999 study by Divale similarly demonstrated correspondence between cultural complexity—assessed through indicators of food resource management strategies, such as storing grain for subsequent years—and number systems complexity). That is, timekeeping by quantification is made possible by the availability of numbers, which in turn develop greater complexity in response to cultural factors. This nexus of cultural complexity, number system elaboration, and the quantification of time suggests that an artifact used for timekeeping tells us something about the society that made it, not only things like the sedentism needed to make long-term celestial observations and the division of labor supporting the development and dedication of specialization to collecting celestial information, but also their number system. That is, the quantification of time is associated with counting to higher numbers, which in turn are associated with the use of material technologies for counting.

For example, consider the artifact from Abri Blanchard, which the experimental recreation of ancient astronomical techniques suggests recorded the lunar analemma, the closed curve made by the moon's nightly maximum height, and lunar phases, the waxing, full, and waning shapes (Marshack, 1991; Jègues-Wolkiewiez, 2005; also see Fig. 1a and b). Such detailed, materially based timekeeping is arguably distinct from the behaviors seen when

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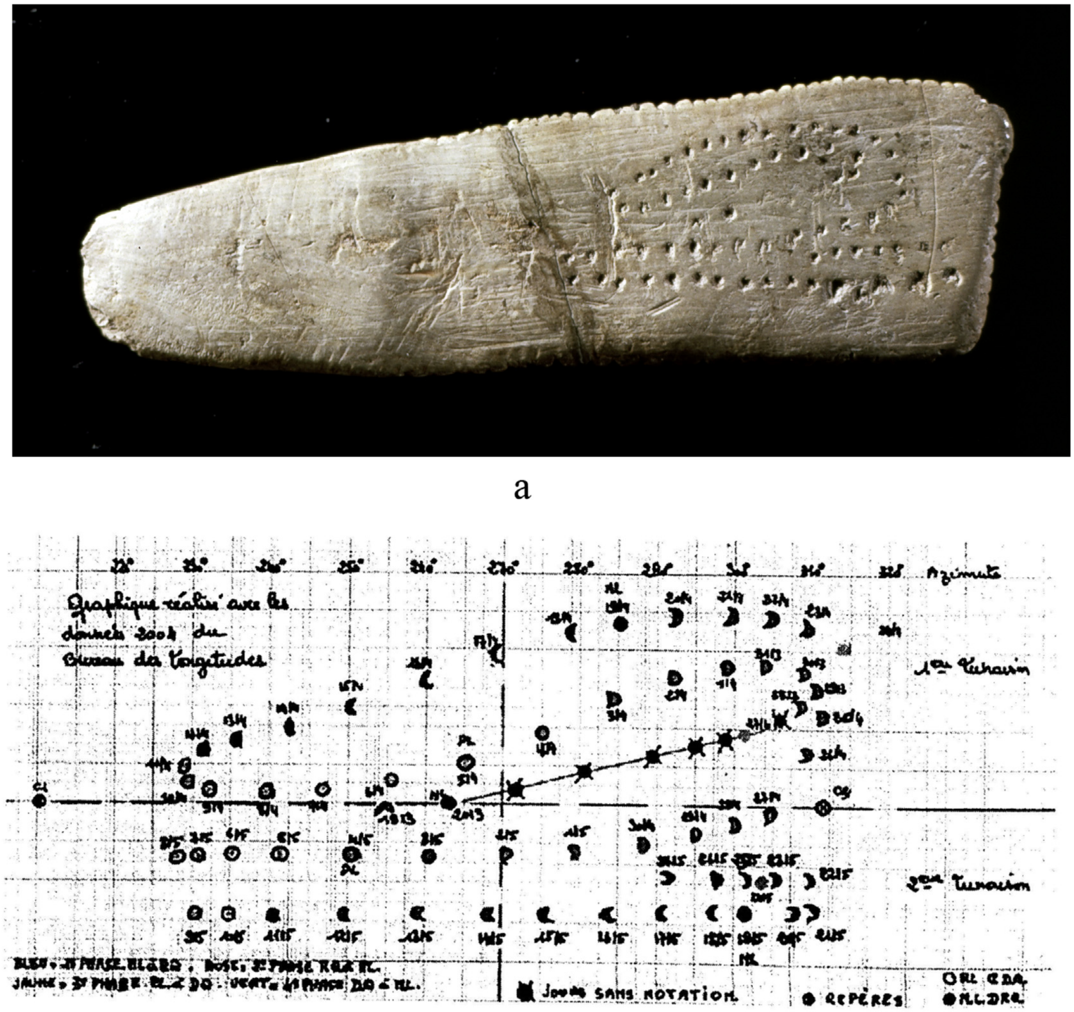

a

b

Fig. 1. a. Abri Blanchard artefact, *c.* 28 ka. The impressions may represent the lunar analemma and phases (Marshack, 1991; Jègues-Wolkiewiez, 2005). Source: Gift of Elaine F. Marshack. Courtesy of the Peabody Museum of Archaeology and Ethnology, Harvard University, PM# 2005.16.2.318.38 (digital file# 98520110). b. Graph made by Jègues-Wolkiewiez (2005) showing 2004 lunar analemma and phases based on data from the Bureau of Longitudes, Paris. The correspondence to the Abri Blanchard artefact is near-perfect. Source: Jègues-Wolkiewiez (2005).

time is initially quantified, which tend to consist of things like counting lunar appearances with tally marks or knots in strings (technologies that themselves tend to be associated with more extensive counting sequences), and thus it suggests the society making the artifact would have had both complex culture and complex numbers.

If the elaboration of numerical systems and the extension of numbers to non-tangible domains such as time are linked to cultural complexity, the reasons for this phenomenon remain insufficiently explored. In the present analysis, Material Engagement Theory (Malafouris, 2013), an emerging perspective in cognitive archaeology, provides a new viewpoint from which to interpret the cultural nexus in which quantification and timekeeping develop and examine the role of materiality in numerical cognition. The insights from Material Engagement Theory are then applied to representative artifacts for quantification that have been dated to the Neolithic (Mesopotamian clay tokens and ancillary technologies), Upper Palaeolithic (notched tallies and hand stencils from Europe), and Middle Stone Age (stringed beads from Africa, the Levant, and the Near East) to suggest that, if they do not represent the practice of quantification, they nonetheless represent opportunities for the development of numerical thinking.

2. The relations between complexity variables

Two studies from 2013 demonstrated links between complexity in culture and number systems. In the first (Overmann, 2013a), the variable for cultural complexity consisted of Hayden and Villeneuve's (2011) dichotomous characterization of culture in a sample of 33 traditional societies as ‘simple’ or ‘complex.’ A measure of numerical system complexity, also dichotomous, was derived from highest number counted as described in the ethnographic literature contained in Yale University's electronic Human Resource Area Files (eHRAF; Biesele et al., 2013). Highest number counted is a frequent measure of number system elaboration because the greater availability of numbers correlates with the likelihood that numerical relationships will be discovered; this is simply a function of increased exemplar availability (in other words, the more numbers you have, the more likely you are to notice the patterns among them; Beller and Bender, 2011).

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