Number^{1,2,3} and Measure^{d,w,t} in Prehistory
Workshop UZH^{ARCH} 2020
Abstracts

Rafael Nuñez (San Diego)

From quantical to numerical cognition: Symbolic reference and the biological enculturation hypothesis

Is there a biologically endowed capacity for number and arithmetic? A widely accepted view in cognitive neuroscience, child psychology, and animal cognition gives an unproblematic 'yes' for an answer to this question, claiming that there is a biologically evolved capacity specific for number and arithmetic that humans share with other species. However, data from various sources —humans from non-industrialized cultures, trained nonhuman animals in captivity, and the neuroscience of symbol processing in schooled participants— do not support this view. The use of loose and misleading technical terminology in the field of "numerical cognition" has facilitated the elaboration of teleological arguments which underlie the above view. To understand this, a crucial distinction between quantical and numerical cognition is necessary: Biologically evolved preconditions (BEPs) for quantification do exist (quantical cognition), but the emergence of exact symbolic quantification and arithmetic proper (numerical cognition) – absent in nonhuman animals – has materialized via cultural preoccupations and practices that are supported by language and symbolic reference – crucial dimensions that lie largely outside natural selection. In this talk I'll discuss the biological enculturation hypothesis, which attempts to explain the complex passage from quantical to numerical cognition.

Mateusz Hohol (Kraków)

Geometric cognition: From core systems to artifacts and back again

This lecture focuses on the cognitive development of Euclidean geometry. I will show that to understand how geometric cognition has been constituted, one must appreciate not only individual cognitive factors, such as phylogenetically ancient and ontogenetically early core cognitive systems, but also the social history of the spread and use of cognitive artifacts. In particular, I will show that the development of Greek mathematics, enshrined in Euclid's masterpiece called „Elements," was driven by the use of two tightly intertwined cognitive artifacts: the use of lettered diagrams; and the creation of linguistic formulae (namely non-compositional fixed strings of words used repetitively within authors and between them). Together, these artifacts formed the professional discourse of geometry. In this respect, the case of Greek geometry clearly shows that explanations of geometric reasoning have to go beyond the confines of methodological individualism to account for how the distributed practice of artifact use has stabilized over time. This practice has also contributed heavily to the understanding of what mathematical proof is; classically, it has been assumed that proofs are not merely deductively correct but also remain invariant over various individuals sharing the same cognitive practice. Cognitive artifacts in Greek geometry constrained the repertoire of admissible inferential operations, which made these proofs intersubjectively testable and compelling. By focusing on the cognitive operations on artifacts, I will also stress that mental mechanisms that contribute to these operations are still poorly understood. While there are theories suggesting that mathematical reasoning, in general, relies on perceptual capacities and external notation, there are no worked-out accounts of reasoning using geometric symbols. External cognitive artifacts would only make the deductive operations more stable as they would no longer rely only on imagery. Another possibility is that there are two different systems of operations of reasoning, which would be consistent with the general functional separation of the core systems and the more enculturated part of mathematical cognition.

Karenleigh A. Overmann (Bergen/Colorado)

The curious idea the Māori once counted by elevens, and the insights it still holds for numerical research

Our ideas about numbers in prehistory are largely based on artifacts found in the archaeological record. This approach carries inherent risks in that not every artifact used for counting is deposited, not every artifact deposited is later discovered, and not everything discovered is unambiguous regarding its possible use for numerical purposes. There are two further challenges in a materially based approach to ancient numeracy: First, correctly interpreting numerical artifacts means understanding what numbers are as concepts and how material forms inform what they are as concepts. Second, there are devices for counting that would not leave any archaeological trace but which do contribute materially to what numbers are as concepts. Both these further challenges are illustrated by means of a historical oddity, the curious idea the Māori, the indigenous people of New Zealand, once counted by elevens.

Richard Seaford (Exeter)

Number and Value in Early Greece

I propose to describe and discuss the social function of numerical measurement in three successive phases of ancient Greek prehistory and history, for which our evidence is not only archaeology but also (a) the Linear B texts, (b) Homeric epic, and (c) texts of the sixth century BCE (inscriptions, the Laws of Solon, presocratic philosophy). The numerical measurement of *value* is absent from (a), occasionally present in (b), and widespread in (c). This development, which results from monetisation, should also be understood in relation to the persistent premonetary social function of typical numbers as guiding practice (in ritual, tribute, etc.): for instance, in the sacrifice of 9 or 100 bulls the typical numbers 9 and 100 do not of course measure economic value, but they do (e.g.) endorse the value of the sacrifice as generally acceptable to men and to gods. It is worth investigating the historical relation of this social function of number, which deploys the *co-ordinating* and *differentiating* functions of number, with its subsequent and more obvious function as measuring economic value, which deploys the function of number as *equivalence*.

Lorenz Rahmstorf (Göttingen)

Highly composite numbers and the early use of weights

The concept of measuring mass by weighing emerged in the late fourth and early third millennium BC most likely in Egypt and Mesopotamia. Only a few hundred years later weights are also known in the Aegean and Anatolia in the west and the Indus region in the east. Divisibility is an important characteristic in practical weight use. Highly composite numbers (like, 4, 6, 12, 24, 36, 48, 60, 120, etc.) are positive integers with more divisors than any other positive integers have. They were first systematically investigated by the Indian mathematician Srinivasa Ramanujan in the early 20th century. Weight values of weights from Mesopotamia and the Aegean will be investigated in this contribution in regard to their divisibility. When Marvin A. Powell asked in 1973 “why did the Sumerians count in multiples of sixty” he was not able to give an answer. The rather simple answer is that the Sumerians used the advantages of the highly composite numbers for metrology in order to achieve maximal divisibility of products like metal, wool or grain.

Thibaud Poigt (Bordeaux)

Numbers and Measurements in Western Europe during Late Prehistory: the example of Iron Age in the Iberian Peninsula

Studies focused on ancient metrologies and the development of counting concepts are still rare for the pre-Roman Western Europe. The lack of written sources describing such practices explains partly this disinterest. But it can also be credited to the strong idea of a late importation of that knowledge in the Western World by Central and Eastern Mediterranean people. However, the most ancient evidences show that peoples from several areas (Alpine Lake Dwellings, South-West of Iberian Peninsula, North of France, South of England) used scale and weights attached with complex metrological systems since at least the Late Bronze Age (13^{th} – 9^{th} c. BC). The high degree of complexity of some weighing systems left marks in the archaeological record but also indicates the ancientness of such imbedded concepts. One of the best examples for trying to understand the evolution of counting and weighing systems in Western Europe is the Iberian Peninsula. With the use of a homogeneous type of weights since the Late Bronze Age to the Roman Period (i.e. a period of approximately one millennium), this area corresponds to a very good observatory of practices linked with numbers and measures during a large period of time. Furthermore, the history of Iberian Peninsula is marked by a strong interaction with foreign peoples during the all "Protohistory" (Atlantic World, Mycenaeans, Cypriots and Phoenicians during the Bronze Age, Greeks, Punics, Gallic peoples and Romans during the Iron Age). As elsewhere, the presence of scale weights in Iberian Peninsula is often attributed to a Phoenician or Greek contribution. Nevertheless, the observation of diachronic features allows to propose a more complex explanation taking into consideration clues of a strong and local legacy of counting and measuring concepts confronted to new and foreign practices.

This paper aims to present a brief overview of the weighing artefacts and practices identified in Western Europe for the Bronze and Iron Ages. Then it will focus on the specificities of the Iberian Peninsula and what can be deduced from it about the general place of numbers and measurement in Late Prehistory societies.

Jadranka Gvozdanović (Heidelberg)

Development of numeral systems

Counting starts with identification of countable entities, a process in which culture plays an important role. However, counting by numbers and their linguistic correlates, numerals, involves relatively abstract principles by which the number elements and the bases are mutually related. The basic principles involve ordering and mathematical operations. Somewhat surprisingly, there is not a specific numeral type of a continent, but only relatively minor variation. This shows that numeral systems reflect very basic principles of ordering and structure-building that can be assumed to lie at the basis of the human cognition (cf. a.o. Gvozdanović 1999).

Recurrent ordering of natural phenomena (functionally conceptualised e.g. by means of fingers and toes e.g. in Papua New Guinea, or projected as moon phases underlying the concept of months) already in prehistory led to development of numeral bases and elements. A numeral base is a building block, a set of elements *n* that can be used to expressions of the form *xn+y* (i.e. it can be multiplied by another numeral and an additional numeral value can be added to it, cf. also Comrie 2005). Prototypical bases are: quinary (5), decimal (10), pure vigesimal (20), decimal-vigesimal (10-20), and hexagesimal (60). The paper also discusses duodecimal (12) sets used for fractions and multiplication (e.g. for North-European big hundreds, cf. Justus 1996). Numeral bases participate in operations of addition, subtraction, multiplication, division and exponentiation (e.g. in Ancient Egyptian and Sumerian); combinations with numeral elements underlie more restrictions (cf. e.g. Gvozdanović 2006).

Properties of numeral systems have often been discussed and patterned (e.g. recently for Pama-Nyungan by Zhou & Bowern in terms of Bayesian philogenetics). However, entanglement of numeral systems with number and other grammatical properties has usually been left out of consideration, although – as this contribution aims to show – it sheds additional light on the systemic properties of numeral systems.

This paper focuses particularly on decaying and growing numeral systems (decaying in the sense of being overlayered by another, socioculturally more dominant system). Cases in point are Tibeto-Burman systems of Nepal (Gvozdanović 1985) compared to Pama-Nyungan systems of Australia (Zhou & Bowern 2015). Insights about bases and elements deriving from these systems will then be compared with Indo-European evidence (from Gvozdanović 1992).

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Aleksander Dzbyński (Warsaw/Zürich)

Between east and west. Number and measure in the Prehistory of Europe and the Near East

A number of artefacts made of metal in Europe before the Bronze Age unambiguously shows that they were measured and perceived numerically. They are usually described as beads, wires and sheets of metal. A number of tokens, made of clay, has also been found in southern and eastern Europe in the Neolithic but, unfortunately, we still don't have an appropriate idea how to interpret them. Are they to be interpreted similar as their near eastern counterparts? Or has their role changed after arriving to Europe and the following adaptation to local cultures? Moreover, there is a group of other evidences and indices showing that the number and measure development was a continuing process not only in the Near East but also in the Neolithic and Eneolithic in Europe. In this paper, I would like to present a kind of summarizing attempt of how the main development paths of Europe and the Near East can be interpreted. On the one side, we have the Near Eastern phase of number and measure development which had been constituted by artefacts like tokens that led in the subsequent phase to the establishment of full numeracy, literacy and centralized power. In Europe, however, we see a strong current of early metal production that introduces number and measure, as it seems, by another means of cognitive conceptualization. The interpretations presented reveal series of questions concerning historical, cultural and cognitive processes on both sides of the Old World.