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In terms of morphology, the distinctiveness of the parietal areas in modern humans is patent (Bruner 2004; Bruner, De la Cuétara, and Holloway 2011a; Bruner, Manzi, and Arsuaga 2003; Gunz et al. 2010). Differences and variations in the parietal lobes have always been a major topic in paleoneurology, dealing with the origin of hominoids (Holloway 1981), of hominids (Dart 1925), and of the human genus (Tobias 1987; Weidenreich 1936). Taking into account the possible involvement of these areas in simulation, mental experiments, and the generation of a virtual world through the eye-hand "ports" (Bruner 2010), it seems reasonable to suggest that many numerosity functions can be directly related to the networks of the parietal areas (mental representations, internal concepts, serialization, and ordinality). The converging results on the role of the intraparietal area from paleoneurological (Bruner 2010), cytoarchitectonic (Orban et al. 2006), and functional (Ansari 2008; Cantlon et al. 2006) analyses further suggest possible common frameworks. We can thus surely state that the hypothesis is largely in agreement with the fossil record, which shows anatomical changes in modern humans associated with parietal areas involved in functions that are part of relevant processes also involved in numerosity. At this point, the issue of polarity comes to the fore. As for the bird's beak, on the one side we have expanded parietal elements, while on the other we have complex behaviors. Were those parietal components selected after evolutionary pressure on a specific behavioral capacity (in this case, numerosity), or alternatively is this capacity a useful constraint/by-product of our brain configuration? Is numerosity a selected ability, able to influence fitness sufficiently to induce an adaptive cognitive shift? After all, even if numbers "apply to everything," hundreds of thousands of animal species have almost no idea about this, and their fitness is incredibly good anyway.

We must carefully take into account that all these cortical districts are central to overdistributed networks and particularly that their functions are largely integrated into a frontoparietal system, which should not be dissected into discrete units (Culham and Kanwisher 2001; Hagmann et al. 2008; Jung and Haier 2007). Interestingly, the form variation of deeper parietal areas has been also related to patterns of brain morphological integration (Bruner, Martin-Loeches, and Colom 2010) and mental speed (Bruner et al. 2011*b*). Even if this may be a real biological/evolutionary signal, we must take into account that the central position of these areas in terms of topology and neural networks make them sensitive to many different direct and indirect sources of change.

Numerosity is a relevant issue in the origin of the modern mind, and I agree that changes at the parietal areas may have been directly involved in this process. At the same time, these cognitive abilities cannot only be related to a single event or to a single cause, being more likely the result of a more complex integration between different and relatively independent neural substrates, probably through feedbacks with nonbiological factors associated with the dynamics of cultural transmission.

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Are Numbers Special? Cognitive Technologies, Material Culture, and Deliberate Practice

The human ability to engage in abstract, stimulus-independent, computation-hungry forms of cognition has intrigued archaeologists, psychologists, and philosophers for decades. Why is *Homo sapiens*, more so than other animals, able to engage in these types of reasoning? Many scholars have approached this question by proposing one or a few key changes in human cognition as the catalyst for human-specific abilities, including sharing intentionality (Tomasello and Carpenter 2007), pretend play (Carruthers 2002), and the ability to reason about structural higher-order relationships (Penn, Holyoak, and Povineli 2008). Coolidge and Overmann provide an interesting addition to these theories in their argument that numerical cognition provides the precursor to our ability for abstract thought.

Developmental and neuroscientific evidence is compatible with an alternative view that regards number as one among several cognitive technologies (Frank et al. 2008). Humans depend extensively on alterations of their environment for their survival. Technologies, such as stone-tool knapping or fire making, accomplish such alterations. They rely on human cognitive and physiological adaptations, but they require additional practice and instruction. Cognitive technologies also rely on human feral cognitive and physiological adaptations, which they extend in culture-specific ways. They differ from other technologies in that they are not aimed at altering our physical surroundings but at transforming our cognitive environment. They alter its informational character, among others, by making some of its features more salient (Sterelny 2010). We do not physically alter a terrain by drawing a map, vet using a map makes it easier to navigate; a calendar does not alter time, but it allows us to record cyclical events that would otherwise escape our notice and to plan more efficiently (De Smedt and De Cruz 2011). Other examples of cognitive technologies include language, which helps humans to manipulate, communicate, and focus on abstract ideas (Jackendoff 1996); music, which alters mood, fosters group cohesion, and communicates ideas that are not easy to express linguistically (Patel 2008); and literacy, which allows us to store, manipulate, and transmit ideas with greater accuracy than would be possible through speech alone.

Numbers are cognitive technologies because, as Coolidge and Overmann recognize, they constitute "an important and possibly universal principle of cultural organization (i.e., even where material culture is relatively limited, numbers enable their possessors to ensure trade equity, plan future harvests, etc.)." They rely on innate human numerical capacities but

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require additional cultural elaboration as well. Natural number concepts, although widespread, are not universal; numerical concepts such as fractions, zero, or negative numbers are rare and require specific cultural circumstances, for example, the presence of a positional numerical notation system for the development of zero (De Cruz and De Smedt 2010).

How do humans accomplish the extension of their feral cognitive capacities in their cognitive technologies? One way is through deliberate practice, which results in a reshaping of neural structures in order to be better adapted at their new tasks. For example, the neural effects of literacy can be seen in changes in white matter and corpus callosum density (Carreiras et al. 2009). These neural changes can be explained by the well-known principle of Hebbian learning, where a repeated and persistent excitement of one neuron by another results in metabolic changes in both cells that increases their connectivity (long-term synaptic potentiation). In the case of number, cultural exposure to symbolic numerical representations could result in long-term synaptic potentiation between areas such as the IPS and the AG. The linkage between IPS and AG is thus not only the result of human-specific neural specializations but is also partly due to deliberate mathematical instruction and practice that fosters long-term connections between these areas. Indeed, as the authors point out (following Zamarian, Ischebeck, and Delazer 2009), the effects of arithmetical practice can be seen in a greater activation of AG and less recruitment of IPS.

A second way to extend our cognitive capacities is through material scaffolding, where internal cognitive resources are supplemented with external ones. In the case of arithmetic, humans rely on a variety of material supports, including finger counting, tallies, and abaci (De Cruz 2008). The occurrence of ancient tallies and calculators of at least 30,000 years old suggests that this practice is central to human numerical cognition. Such external practices have an impact on the neural level as well: Chinese and Westerners have differing neural signatures of arithmetic, with a greater contribution of language-related areas in Westerners, a result of rote learning of arithmetical facts, and a greater involvement of the premotor area in Chinese speakers, presumably as a result of instruction through abacus calculation (Tang et al. 2006). In sum, although the architecture of the human parietal cortex may have facilitated human-specific numerical cognition, the unique reliance of humans on material culture, instruction, and deliberate practice has played a crucial role to develop numbers into a cognitive technology.

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Coolidge and Overmann argue that numerosity, the ability to appreciate and compare nonsymbolic quantities of items, may serve as a possible evolutionary cognitive basis for human abstraction. Their article offers, no doubt, a fresh way to look at the origins of symbolic thinking. The contribution they make lies in recognizing that the neurological substrate for numerosity-comprising primarily the IPS, the AG, and the SMG in the inferior parietal lobes-may have also provided a potential means of bridging the world of sense perception and symbol by way of metaphor. Naturally, the attempted synthesis can only be incomplete. Regrettably, the timing or sequence of these critical events in the development of numerical thinking and their precise relation with the archaeological record remain vague. Putative recording devices such as the 14,000-year-old Tai plaque, briefly discussed, provide at best evidence for concrete counting (one-to-one correspondence of quantity) and tell us very little about the emergence of number concept. Yet those limitations should prompt us to question the archaeological record for more supporting evidence and challenge our current theoretical presuppositions. In the following I want to focus on a question that I feel may hold the key to a better understanding of the evolutionary processes that Coolidge and Overmann discuss: how did humans develop the concept of number?

As Coolidge and Overmann discuss, numerosity is an evolutionarily ancient biological competence shared by preverbal infants and nonhuman animals. Indeed, humans are not unique in their ability to extract numerical information from the world. And yet moving beyond this "basic number sense" (Dehaene 1997) of subitization and magnitude appreciation presupposes a mental leap that no other animal seems capable of doing (e.g., Biro and Matsuzawa 2001). What is it, then, that drives the human mind beyond the limits of this core system? Many researchers would claim that it is language (the presence of number words and verbal counting routines) that enabled humans to move beyond the threshold of approximation (see Gelman and Gallistel 2004). But from a long-term archaeological perspective, language cannot account for the emergence of exact numerical thinking in those early contexts where no such verbal numerical competence and counting routine could have existed. I should explain that what we seek to understand here should not be confused with how children nowadays map the meaning of available number words onto their nonverbal representations of numbers. My concern is not with the semantic mapping process by which a child learns number words or to associate, for instance, the word "ten" with the quantity 10. My question instead is about how you conceive or grasp the quantity of 10 when no linguistic quantifier, or symbol to express it, is yet available. The latter does not refer to a process of learning but to a process of active discovery or enactive signification (Malafouris 2008, 2010a). I suspect that despite the evident association between language and exact arithmetic, language lacks in itself the necessary "representational stability" (Hutchins 2005) that would have made possible such a transition. How did we do it then?

Elsewhere I have tried to answer that question focusing on the Neolithic Near Eastern accounting system (Malafouris Coolidge and Overmann The Emergence of Symbolic Thinking

in the abstraction process (or higher-level abstraction) may be unique to modern humans. Finally, our extension of the dual systems of numerosity as a tentative foundation for humans' intuitive penchant for analogies and metaphors not only remained unscathed in the commentaries but untouched; we look forward to future dialogue on this part of our argument, as a recent book (e.g., Geary 2011) has highlighted the ubiquitousness of metaphors and their centrality to modern thinking. As Geary provocatively yet cryptically noted in his foreword, "Metaphor is a way of thought long before it is a way with words" (Geary 2011:3), which is completely consonant with our central thesis.

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