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Extending the mind, embodying cognition: new light on old endeavours

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Since everybody has access to part of own cognitive processes, everybody knows something about cognition. However, cognition or, namely, cognitive science, is a scientific discipline and, as such, it is the matter of specialized scientists who devote their academic and research efforts to better know and in deep what, how, when, and why cognitive processes occur. For better or worse, long-term cumulated knowledge in cognitive science -outstandingly boosted in the last decades by modern brain-imaging techniques- has generated a plethora of empirical facts and statements most of them amazingly counterintuitive. Issues of concern such as consciousness, decision making, problem solving, language, perception, or action, to name just a few, have nothing or little to do with what introspection might reveal.

In the field of human evolution, a remarkable topic of interest is the evolution of the mind, or *evolution of human cognition*. Indeed, cognition is probably the most outstanding difference between ours and other extant species, and it could be inferred that, to a greater or lesser extent, this has been the case as well when considering extinct human species. Human cognitive evolution is a laudable scientific inquiry. However, the field has been mostly attempted by archeologists; unfortunately, with few and noticeable exceptions, cognitive archeologists are not cognitive scientists. That is to say that a bulk of authors inquiring on how the human mind might have been in the past are not true specialists on how the human mind might be at present. As a result, cognitive archeology texts abound in assumptions somewhat bewildering to a cognitive scientist, such as that s*ymbolically mediated behavior* is an unchallenged and universally accepted marker of modern human mind (e.g., dErrico *et al.*, 2005). The statement can simply not be accepted by a current cognitive scientist; among other things, gorillas and chimpanzees are able to exhibit symbolic behaviour to the extent that they can link amodal, abstract, and arbitrary representations with semantic or conceptual knowledge (e.g., Beran *et al.* 2000).

In cognitive science, the symbolic perspective is being replaced by alternative models of *embodied cognition*, according to which mental representations are directly grounded in sensorimotor experience (e.g., Barsalou 2008; Caligiore & Fischer 2013). From an embodied perspective, symbolism should better be replaced by *abstraction* and *integration*, two terms directly related with perceptual and action principles working in the brain according to neuroscientific traditions (Fuster, 2003). The brain is thus conceived as a memory system solely devoted to perception and action. A variation or, conceivably, an extension of the embodied perspective is the so-called *extended mind* perspective originated in philosophical frames. The idea posits that the mind would not end at the boundaries of the body; instead, objects, tools, and other environmental entities can also be considered as proper parts of the mind (Malafouris, 2013).

It seems that something is moving in the fields of cognitive science and philosophy of the mind, something of great relevance for better understanding the evolution of the mind. Remarkably, symbols seem to be losing prominence while our body and our environment as part of our thinking appear to be gaining it. I sincerely applaud

the initiative by Emiliano Bruner & Marina Lozano of incorporating current perspectives of the human mind to inquire about its evolution. Providentially, cognitive archeology is beginning to endorse current scientific views.

In their article, the authors speculate with the aim of explaining why *H. heidelbergensis* and Neanderthals exhibited an extensive use of the mouth as a "third hand" whereas this behavior represents less than a 50% in modern human hunter-gatherer societies. To do this, the authors ground their suggestions on empirical findings of which both the embodied and the extended mind perspectives would respect as of high relevance. First, they consider the brain parietal bulging proper of our species, and interpret it in terms of the interactions between the individual and the environment, in line with embodied and extended mind models. However, the functional complexity of the parietal cortex (e.g., Orban *et al.*, 2006) and the fact that parietal functions may largely vary between brain hemispheres suggest that Bruner & Lozano's claim is somewhat incomplete at this point. Functional interpretations for the modern human parietal bulging are still speculative and largely provisional.

Better established are their second and third empirical supports, that is, functional adaptations in modern human's hand and changes in material culture. Indeed, the hand evidence alone would suffice to stand out that changes occurred in cognition as well. By changing the ways the hand interacts with the world, embodied and extended mind perspectives would predict relevant changes in the way our species would think. It is important to stress in this regard that outstanding differences exist between modern humans and extant primates on the neural circuits directly controlling the hand -namely the *corticospinal* system for fine voluntary movements of the fingers. Only in humans and the most dexterous primates there are terminations of this system directly onto the spinal motor neurons innervating the most distal muscles, humans presenting the overwhelmingly largest number of these terminations (Passingham, 2008). There has also been a considerable increase in humans of the portion of the corticospinal system devoted to control hands and wrist (in both the motor and sensory aspects); though the hand of the chimpanzee is larger, the cortices for the hand are three times smaller. Although we do not know the values for these neural parameters in extinct human species, the differences in functional musculoskeletal dynamics outlined by Bruner and Lozano would warrant neuroarchitectural dissimilarities.

Differences in motor control between extant and non-extant species, even if apparent, have largely been overlooked in approaching across-species differences in cognition. Encompassing the embodied and extended mind perspectives with cognitive archeology should change the situation. Bruner and Lozano's proposal is in this line, and indeed neural and musculoskeletal dynamics of the hand are also of relevance in recent proposals on the origins and evolution of art (Martín-Loeches, 2013).

Changes in the brain, the material culture, and the hand permit Bruner & Lozano suggest an explanation to the differences between species in mouth use as a "third hand". Surely, this is a good idea and is at least bringing to light a possibly relevant clue in explaining the archeological record from the embodied and extended mind perspectives. However, in my view, that using the mouth as a third hand obeys an incapability to assume increased cultural complexity seems a bit daring. At least some details are missing; otherwise it is difficult to appreciate how past human brains were able to create cultural complexities hardly assumable by themselves, and that this occurred across two different and long-lasting species. But once the idea by Bruner & Lozano has been launched, later developments are encouraged, and expected to be fruitful.

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