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How Things Shape the Mind: A Theory of Material Engagement. Lambros Malafouris. Cambridge, Massachusetts: MIT Press, 2013, 305 pages, $ 40.00 hardcover.

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How Things Shape the Mind: A Theory of Material Engagement represents a synthesis of the positions that the author, Lambros Malafouris, has developed over the course of his career, supplemented by the addition of new explanatory examples and unpublished chapters. The main objective of the book is to provide a unitary account of material engagement theory, the actual keystone that binds the multiple streams of argument presented by the author in his previous works. The book is organized in three main sections, which respectively take into account epistemological aspects, theoretical tenets, and empirical applications of material engagement theory.

A large part of the *pars destruens* within the book is dedicated to undermining the foundations of a mentalistic and internalist perspective in both cognitive archaeology and philosophical anthropology. Section I (chapters 2 and 3) offers a synthesis of the theoretical problems that plague these traditional approaches. At the same time, this section illustrates how material engagement theory allows us to rethink the archaeology of mind by overcoming the drawbacks with the standard proposals.

Malafouris argues against the coalescence of mutational enhancement[1] (Klein, 2008, 2009) and classic forms of evolutionary psychology (Barkow, Cosmides and Tooby, 1992) in explaining the aetiology of human cognitive becoming. He criticizes the idea that the human mind ought to be conceived as a combination of native functional modules, shaped by natural selection (e.g., Mithen, 1996). According to this perspective, the incurrence of a mutation in a hard-wired module can provide humans with appropriate representational substrates, which are then used to solve

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[1]Mutational enhancement implies that human cognitive abilities can be augmented by means of selective mutations in the underlying neural architecture. Such biological alterations produce enhanced humans that are provided with a more adaptive cognitive system. This allows enhanced humans to replace the unenhanced phenotypes on the long-term evolutionary scale.

adaptive problems within the environment. The emergence of cave art in the European Upper Palaeolithic might be thus considered as the result of a passive Darwinian mechanism. Art is selected as a sophisticated behaviour that is needed to solve specific social problems, such as, for example, providing emotional stability, maximizing interpersonal bonding, or providing a non-violent context for mate-selection (Dissanayake, 2009). To these purposes humans evolve appropriate neural substrates and cognitive abilities that make them "born to artify" (Dissanayake, 1992). Equipped with such representational substrates, agents first become capable of representing an animal in memory space. That is, human agents could now be aware of the existence of a particular animal representation in their minds. Then, they could contrast the properties of pigments with those of the cave wall and infer that colours could be used to copy a representation of an animal they held in mind. In this way, humans impose an a priori envisaged mental image to matter.

In contrast, Malafouris proposes a theory of the engagement of humans and artefacts that combines elements of classic embodiment/extended mind with more radical aspects that aim to minimize the necessity of mental representations and computations in favour of dynamic human-artefact systems. In the three chapters that compose section II, Malafouris defines the core tenets of material engagement theory. His approach consists in providing multiple lines of argument to defend the central thesis that human minds, bodies, and artefacts are inextricably linked by a constitutive relationship. In the first place (chapter 4), Malafouris discusses the boundaries of the mind under the perspective offered by extended mind theories (e.g., Clark, 2008). He focuses on the hybridization between human bodies, minds, and artefacts to reject the idea that the mind is only limited within the head and is brain-bound. At the same time, Malafouris argues that formulating a proper theory of extended mind requires abandoning anthropocentric theories of intentionality and agency. According to these approaches, a theory of extended mind would imply that artefacts are passive items that are simply integrated within the cognitive system of the human agent, who imposes decisions onto them. In contrast, Malafouris redefines a theory of agency (chapter 6) by focusing on the active role that artefacts hold in shaping human mind and behaviour. Artefacts are thus intended to actively participate in the cognitive processes by deeply altering the dynamics of human action and perception. For instance, the clay manipulated at the potter wheel (chapter 9) does not limit itself to passively accommodating the potter's decisions and actions. Through its properties, the clay acts upon the potter, constraining the artisan's decision-making process and the unfolding of actions.

On these grounds, Malafouris develops the core argument that the enactive engagement with artefacts leads to the emergence of new cognitive and behavioural possibilities for human agents. The main theoretical aspects of this position are illustrated in chapter 5 and supported by means of empirical applications across section III (chapters 7–9). For example, the curved line that is painted on a cave wall during the Upper Palaeolithic brings forth to consciousness the representation of the back of an animal and enables humans to perceive a new reality, which consists of pictorial images. The image and its meaning emerge therefore as a result of human action over matter and through matter itself. This enactive approach allows humans to mentally manipulate the process of production of the same image and to start thinking about what other people think of the images. Therefore, material engagement becomes a necessary condition for the acquisition of new cognitive processes.

The entire book concerns the idea that a slow transformation of the mind, driven by material engagement, represents the engine of human cognitive evolution and leads to the emergence of new technologies in the archaeological record. Symbolism, for example, does not result from a discrete mutational event, which provides humans with symbolic capabilities. Conversely, symbolism must be enacted through a prior stage of engagement with non-symbolic artefacts, which scaffold a gradual metamorphosis of meaning (see chapters 5 and 8 for details). Referring more broadly to the aetiology of the Middle-to-Upper Palaeolithic transition, Malafouris rules out the possibility that discrete mutations could be considered as sufficient conditions for the emergence of cognitive abilities and hard-wired adaptive behaviours that culminated in the ill-famed concept of "behavioural modernity" (chapter 10).

However, limiting the focus on the enactive signification and emergence of cognitive capabilities might lead to the opposite problem of neglecting the role that biology can play in human cognitive evolution. If biology is only one part of the story (Read and van der Leeuw, 2008), then what exactly is its role? The aim of this review is primarily to take into account the problem of biological enhancement in relation to Malafouris' material engagement theory.

Cognitive Equivalence and Material Engagement Theory

The opposite theoretical extreme to the mutational enhancement approach in cognitive archaeology is represented by the cognitive equivalence model (e.g., Henshilwood and Dubreuil, 2011; McBrearty and Brooks, 2000). Proponents of this theory argue that artefacts commonly associated with the European Upper Palaeolithic appear in various African sites earlier in time. In particular, the gradual emergence in the African Middle Stone Age of body ornaments and patterns of marking, which have been considered symbolic, has strengthened the conviction that no form of cognitive enhancement was necessary to explain the Upper Palaeolithic technological explosion. In contrast, scholars refer to a variation in demographic dynamics (Powell, Shennan, and Thomas, 2009; Shennan, 2001) to argue that technological innovations could have been linked to social, if not simply numeric, reasons. Rather than to cognitive limitations, the limited emergence of innovations during the Middle Stone Age has been ascribed to the fact that innovators were not capable of effectively transmitting new technologies to their conspecifics. Success in technological propagation has been associated with the "learning population" size (but see Read, 2012, for a counterargument). The recent ascription of body ornaments to Late Neanderthal populations in Europe (Caron, d'Errico, Del Moral, Santos, and Zilhão, 2011; Zilhao et al., 2010) has led to further radicalize the cognitive equivalence approach. According to this perspective, known as the "cultural school," Neanderthals also could have created "behaviourally modern" artefacts, prior to the interaction with modern humans. Such an idea was used to conclude that the fundamental bricks of modern human cognition were already present in human populations since the Middle Pleistocene (d' Errico and Stringer, 2011; Zilhao, 2011a, 2011b). I assume that the various cognitive equivalence positions share the basic conviction that a mental architecture typical of Upper Palaeolithic populations was already present in more primitive humans. At the same time, these positions differ on whether this mental architecture also applied to archaic lineages like Neanderthals.

However, cognitive equivalence proposals tend to neglect specific analyses of the mapping between mental architectures and the archaeological record (Garofoli and Haidle, 2014). While they assume that cultural, social, or demographic mechanisms are able to replace the need for mutational enhancement, they do not provide any cognitive and neurological mechanism that explains the rise of technological innovations.

The limited attention provided to what happens within the "black box" risks reducing cognitive equivalence proposals to behaviourist theories. Indeed, it might be argued that demographic/environmental variations altered human dispositions for behaviour, which in turn affected the behavioural outcomes, leading to a consequent raise in technological sophistication.

The cognitive equivalence agenda can attempt to fill this lacuna about the mechanism of cognitive evolution by focusing on the concept of metaplasticity. This notion is central to Malafouris' book (see pp. 45–47) and stands at the crux of the neuroarchaeological approach (Malafouris, 2009, 2010a). It entails that the enactive cognitive transformation (introduced above) is supported by phenomena of neural plasticity induced by experience. These in turn lead to restructuring of both the structural and the functional brain architecture. As a result, new possibilities of technological development emerge, which produce further neural alterations, thus creating a snow-ball feedback of mutual interactions between these levels. Such a plasticity process does not simply imply a passive accommodation of the neural system to the requirements imposed by the new tasks. Most importantly, it is argued that the engagement with tools might lead to the enactive emergence of new cognitive abilities.

Malafouris gives substance to this point by referring to a body of evidence in comparative primatology (pp. 164–167). In particular, macaques have been shown to be able to embody a tool and to perceive new affordances for action that the tool provides (Iriki and Sakura, 2008). In a first experimental stage, macaques took two weeks to learn that a rake could be used to retrieve food from a location that lies beyond the reach of their arm. After this long-term engagement with the tool, however, macaques became capable of perceiving what the rake affords to do. Without any form of specific training, the monkeys immediately recognized that a rake affords taking another longer one, which in turn could be used to reach the food. This process was coupled with a functional restructuring in the connectivity of the parietal cortex. In a similar fashion, human cognitive evolution might be explained as a gradual process of plastic rearrangement of the neuro-cognitive system.

In consequence, it might be argued that the environmental and demographic variations advocated by proponents of cognitive equivalence created the appropriate conditions that led human agents to engage with some material scaffolds in the African Middle Stone Age. Innovations emerged as a result of this preliminary engagement and were coupled to the metaplastic rearrangement of neural substrates. This combination of cultural school aspects with the mechanism of plasticity suggested by Malafouris appears prima facie capable of explaining the technological explosion registered in the Middle-to-Upper Palaeolithic transition. In sum, the same neural architecture, shared by different human species since the Middle Pleistocene, might have gradually transformed itself by remodelling its structure through metaplastic mechanisms. This would rule out the idea that mutational enhancements of any kind are necessary for justifying the emergence of Upper Palaeolithic material culture.

However, this solution leaves room for several drawbacks. In fact, the idea that plasticity mechanisms could be advocated to reject mutational enhancements originates from a theoretical misunderstanding of some of the material engagement theory premises. It is therefore necessary to clarify this point in order to avoid confusion. In the next section, I will attempt to demonstrate that material engagement theory, and in particular the notion of metaplasticity, are orthogonal to the problem of mutational/biological enhancement and cannot be used in principle to support the existence of a mere culturally driven mechanism.

The "Limitless Plasticity" Fallacy

Material engagement theory adopts neuroconstructivism (Mareschal et al., 2007; Westermann et al., 2007) as a background theory for cognitive development. The main idea at the basis of this theory is that the human mind is not constituted by native modules, which are hardwired within the neural system by natural selection. In contrast, modules are *acquired* along a process of multilevel interactions, which range from the cellular level to the cultural one. Native properties of interacting neural cells, layers, cerebral regions, body systems, etc. have the role of constraining the culturally situated process of cognitive development. These biological constraints alter the probabilities that the interaction with the environment will lead to the emergence of a specific cognitive function (Gottlieb, 2007). Neuroplasticity, in turn, warrants the very existence of potentially different functional states within the same structural levels. By the lights of material engagement theory, the embodiment of artefacts in the human cognitive system represents an additional level within this intricate constructivist process.

However, a clarification needs to be provided when dealing with the neuroconstructivist account. As discussed above, this theory entails that phenomena of neural plasticity are limited by native constraints. By neglecting this critical aspect, we would be led to conclude that neuroplasticity is limitless. In this way, any structural architecture and cognitive function can be in principle constructed, if the proper conditions of human–environment interaction are provided. Such conception implies that constraints to plasticity are not native, but also acquired. Since native constraints are to be intended as physical properties and relationships between neurobiological units, we are left with the idea that some environmental interactions can upset these deep properties and adapt them to the context.

The flaw lies here in conflating the concept of "constructing" with that of "creating." Referring to the hypothesis of neuronal recycling (Dehaene and Cohen, 2007), as Malafouris (2010a) does in one of his previous works, it is possible to have a clearer view of the problem. The very notion of recycling entails that some neural regions previously dedicated to some tasks are readapted to cope with new ones. Spelled out in neuroconstructivist terms, this implies that the interacting biological levels (cells, layers, gross architecture, etc.) warrant sufficient degrees of freedom to host a different function.

The most problematic distortion that can be made of material engagement theory lies in combining this theory with a limitless plasticity mechanism of the kind described above. In this way, material engagement would not simply elicit a recycling process, which modulates the functional relations among elements within the human brain. It would foster instead the addition of entirely new pieces of neural architecture, provided with a new set of properties and constraints. Cognitive functions that are impossible to be implemented within a specific neural architecture become possible if the proper form of engagement with artefacts is provided.

Let us consider for clarity the example of arithmetic acquisition in children. Malafouris (2012) has recently proposed that arithmetic emerges in development as a consequence of material engagement with non-symbolic tokens. Visual icons, in the form of items or even fingers, are considered to gradually bring forth to consciousness the existence of numeric symbols. Such enactive signification resonates with the hypothesis of neural recycling. Indeed, Dehaene and Cohen (2007) argued that regions in the human intraparietal sulcus are precursors to processing symbolic numerocities both at the phylogenetic and ontogenetic level. In particular, they claimed that morphogenetic constraints within the architecture of these regions might have made them particularly suitable to host arithmetic functions. Contextualizing to material engagement theory, the regions within the intraparietal sulcus are plastically rearranged to support the enactive emergence of numbers.

Now consider the case of a human species that presents an intraparietal sulcus with a different set of morphogenetic constraints. Unlike the standard intraparietal sulcus, this region (henceforth referred to as "pseudo-intraparietal sulcus") cannot be recycled to host symbolic numbers. Even though engaging with non-symbolic artefacts, humans provided with a pseudo-intraparietal sulcus cannot ever shift to the symbolic level, for plasticity is limited by native constraints acting on pseudo-intraparietal sulcus.

The only way to acquire symbols for these humans is to introduce the aforementioned mechanism of limitless plasticity. In this way, provided the right conditions of material engagement with non-symbolic artefacts, limitless plasticity can flank the native constraints of pseudo-intraparietal sulcus by replacing this region with a standard-intraparietal sulcus. The acquisition of symbolic numerocities becomes now possible due to the substitution of one piece of neural architecture with a more advanced one.

This mechanism of plasticity is deeply problematic, for it implies that new pieces of our brain derive from experience. Therefore no mere cultural dynamic is, in principle, sufficient to overcome the problem of biological limits to cognitive properties.

The example Malafouris provides about tool embodiment in macaques is particularly relevant to show the process of enactive signification and acquisition of new cognitive abilities. But how far can this enactive engagement augment the monkeys' cognitive systems? The crucial question lies here in individuating the architectural constraints that limit the further enaction of the macaque cognitive system. There is clearly no doubt that even the most enculturated primates cannot overcome these native limits.

A relevant example from comparative primatology can clarify the problem with the limits of enaction and plasticity. Monkeys have long been considered to be incapable of solving analogical reasoning tasks, in contrast with great apes, who instead solve these problems in a reliable way. The matter is still controversial, provided the emergence of new evidence (e.g., Kennedy and Fragaszy, 2008) that argues against the hypothesis of the "paleological monkey" (Thompson and Oden, 2000) and in contrast to theoretical responses that tend to explain this evidence away (Penn, Holyoak, and Povinelli, 2008). Truppa, Piano Mortari, Garofoli, Privitera, and Visalberghi (2011), in particular, investigated analogical abilities in capuchin monkeys held in captivity. In this study, the monkeys were first trained to solve matching-to-sample tasks of the "A=A and not B" kind. Then, they were presented with relational matching-to-sample tasks of the kind "A–A analogous to B–B and different from C–D." The capuchins repeatedly engaged with a touch-screen system where the stimuli were presented and they solved the initial matching-to-sample task only after several thousands of trials. In contrast, the acquisition of matching rules never allowed them to solve the relational reasoning task, except for one subject. In this way, some critical arguments (Chemero, 2009; Penn et al., 2008) supported the idea that the cognitive limits were flanked by adopting alternative strategies, like the direct perception of figure entropy. This study provides a set of important insights. First, it shows that engagement with the experimental apparatus can lead the capuchins to acquiring at least a novel concept of "matching." Second, it shows that native constraints in the monkeys' neural architecture, presumably related to working memory functions, impeded a straightforward acquisition of analogical reasoning. Third, it shows that the monkeys' cognitive system plastically adapted to solve the task by developing a completely new strategy. If the entropy proposal is valid, monkeys might have recycled the standard matching-to-sample procedure, combining it with the perception of a new invariant element, namely the degree of order perceived within the presented stimuli.

The cases discussed with non-human primates about the limits of enaction raise similar questions when applied to the cognitive archaeology domain. Contextualizing to the example of early modern humans and ochre markings (p. 184), we might wonder whether, from an initial non-symbolic stage of engagement, these populations could acquire an understanding of true symbols without requiring any structural alteration in their brains. A similar issue emerges when taking into account Malafouris' Figure 7.4 (p. 175). In this picture, the author illustrates the enactive emergence of new cognitive abilities during the process of stone tool-knapping, arguing that:

> the knapper first think through, with and about the stone (as in the case of Oldowan tool-making) before developing a meta-perspective that enables thinking about thinking (as evidenced in the case of elaborate late Acheulean technologies and the manufacture of composite tools).

This line of reasoning fosters the idea that the engagement with Oldowan stone tools gradually led to acquiring a meta-perspective, educating the attention of the human agent to shift from the stone tool as a perceptual target to the stone tool as an object of thought. However, whether this shift in perspective is possible or not, it is ultimately a matter of the architectural constraints that regulate that very transition. In this way, there is the possibility that mutational enhancement still represents a necessary condition for acquiring a meta-perspective, even though not a sufficient one, as in the old evolutionary psychology model.

On similar grounds, Malafouris' attempt to eliminate the notion of "cognitive modernity" from the cognitive archaeology vocabulary (p. 242) might be premature. No doubt that the human functional cognitive architecture could be reliably considered as the result of a slow transformative process, which argues in favour of abandoning a nativist conception of cognitive modernity. However, this dynamic variability does not apply also to the structural components of the human mind. Neuroconstructivism allows one to reject the idea that "cognitive modernity" lies in a native asset of "domain-specific" modules, which automatically give rise to a repertoire of modern-like behaviours. However, modernity of a cognitive architecture might still lie in the qualitative properties of some "domain-relevant" regions. Domain-relevent properties are to be conceived in terms of functional flexibility and species-specific constraints on such flexibility. For example, according to the "language as a cultural tool" hypothesis (Everett, 2012), linguistic capabilities are culturally constructed by tapping into regions that have sufficient flexibility to host these abilities. In consequence, it is possible that only a modern "domain-relevent asset" is sufficiently flexible to allow the acquisition of language. Conversely, primitive mental architectures might have insufficient degrees of freedom to support linguistic capabilities, if not subject to a release in their native constraints.

By these lights, technological innovations in human evolution might still require a modern domain-relevant architecture to be developed, which in turn implies natural selection to be obtained. In this way, it appears that the metaplasticity mechanism proposed by Malafouris is orthogonal to the problem of mutational enhancement as a necessary condition to human cognitive evolution.

Future Directions

Malafouris' material engagement theory has two important implications. From one side, it provides persuasive arguments to reject the ill-famed idea of the "magic mutation," as well as neuroreductionist and determinist positions in the anthropological domain (Tallis, 2011). From the other, Malafouris' proposal does not provide an argument for the cognitive equivalence thesis, because it does not necessarily replace the need for mutational enhancement with a mere mechanism of neural plasticity. In fact, the notion of metaplasticity is compatible with the idea that material engagement actively created selective pressures for releasing biological constraints in the brain of extinct hominids. The resulting neural architectures might have offered the proper substrates for the enaction of more sophisticated cognitive processes (see also Hutchins, 2008, p. 2018, for a similar conception of biological fine-tuning). Therefore, a neural system such conceived ought to be sufficiently plastic to accommodate a required alteration at the structural level. In consequence, the addition of new biological properties must occur within the pre-existing structure of a system, without compromising the system's integrity. This adds to the metaplasticity notion a dimension of structural plasticity that speaks in favour of replacing the former term with that of "hyperplasticity." Such a conception maintains the cultural aspects of material engagement while doing justice to the role of biology and natural selection in human cognitive evolution.

A potential opposition between these two conceptions appear evident when applying material engagement theory to the archaeology of the modern human Middle-to-Upper Palaeolithic transitions. In this case, material engagement theory leaves us with two concurrent hypotheses. According to the first, it might be argued that an original domain-relevant modern human cognitive architecture was gradually enacted until it reached the functional aspect shared by most contemporary populations. In this way, body ornaments, ochre markings, bone tools, snaring technologies, etc. in the African Middle Stone Age represent a series of brain-artefact interfaces (Malafouris, 2010b), which restructured the mental architecture in a progressively more advanced way (i.e., metaplasticity). These new substrates led, for example, to the acquisition of symbolic thinking. On the other side, material engagement theory might be compatible also with the idea that the enactive engagement with material culture actively created adaptive pressures that allowed natural selection to gradually transform a primitive mental system into a qualitatively modern one (i.e., hyperplasticity).

The problem of how to select between these contrasting explanations might appear as particularly overwhelming. Indeed, if the two hypotheses are equally constrained by the artefactual evidence and compatible with it, selecting them for their plausibility (Garofoli and Haidle, 2014) could be quite problematic. Eliminative selection can act, however, at a more theoretical level. For example, I venture that plasticity-driven cognitive evolution might be questioned in terms of whether domain-relevant elements are plausibly constrained by the archaeological evidence, prior to their enactive remodelling. In contrast, mutational enhancement proposals might be questioned about the chronology of replacement of unenhanced humans with enhanced ones. In this case, however, enhancement ought to be intended as the trajectory of material engagement that fosters the selection of more advanced mental-architectures.

Concerning the theme of Neanderthal cognitive equivalence, which lies at the heart of the cultural school proposal, the situation might be less problematic. Neanderthal cultural capacity, indeed, cannot be assumed to be identical to those of modern humans by comparing specific instances of their respective cultural performance. The same level of cultural performance in both modern humans and Neanderthals does not allow one to claim that the two species also share the same cultural capacity (Haidle and Conard, 2011). If the use of early body ornaments and bark-pitch hafting (Zilhao, 2011a) does not necessarily entail the presence of a modern mental architecture, then it would be possible to conceive human cognitive evolution under a pluralist perspective. In the context of material engagement theory, this would imply that different cognitive architectures, structured in a different domain-relevant asset, could have engaged with artefacts along alternative trajectories. If so, it is possible that both Neanderthals and modern humans produced early body ornaments, but only the latter ones had sufficient degrees of freedom to transform them into actual symbols. In contrast with the cognitive equivalence agenda, material engagement theory therefore introduces an unprecedented argument. It brings to attention the idea that primitive mental systems also could transform themselves by means of material engagement, reaching a high level of behavioural sophistication.

Conclusions

Material engagement theory represents a groundbreaking approach in cognitive archaeology, since it offers an effective counterargument to several fallacies that currently plague this domain. While it motivates scholars to abandon elements of neurodeterminism and internalism that come with the ordinary accounts, Malafouris' proposal candidates itself to lead a "conservative revolution." Indeed, material engagement theory provides a thoroughly new perspective on "how" cognitive evolution has happened, but at the same time it does not upset some of the fundamental questions concerned with the "what." As I have argued in this review, material engagement theory appears thus to be orthogonal to the problem of mutational enhancement. In consequence, it does not offer support to some extreme cognitive equivalence approaches, for it is compatible also with cognitive pluralism. New opportunities and challenges emerge with material engagement theory, for this proposal allows us to see classic problems in cognitive archaeology under a radically different perspective.

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