Philos. Technol. (2019) 32:243–264
https://doi.org/10.1007/s13347-018-0310-x

RESEARCH ARTICLE

How Stone Tools Shaped Us: Post-Phenomenology and Material Engagement Theory

Manjari Chakrabarty[1]

Received: 30 April 2017 / Accepted: 9 April 2018 / Published online: 22 April 2018

Abstract The domain of early hominin stone tool making and tool using abilities has received little scholarly attention in mainstream philosophy of technology. This is despite the fact that archeological evidence of stone tools is widely seen today as a crucial source of information about the evolution of human cognition. There is a considerable archeological literature on the cognitive dimensions of specific hominin technical activities. However, within archeology and the study of human evolution the standard perception is stone tools are mere products of the human mind (or brain or innate cognitive capacities). A number of recent approaches to cognition challenges this simplistic one-way-causal-arrow view and emphasizes instead the functional efficiency of tools or artifacts in transforming and augmenting human (or hominin) cognitive capacities. As a result, the very idea that tools or artifacts are intimately tied to human cognitive processes is fast becoming an alternative within the cognitive sciences and a few allied disciplines. The present study intends to explore its implications for philosophy of technology. The central objective of this paper is to examine the dynamic and intricate tool-mediated activities of the early hominins through the lens of Don Ihde's post-phenomenological theory of human-technology relations and Lambros Malafouris' Material Engagement Theory. Highlighting the key points where these two research approaches, despite their subtle nuances, converge and look capable of mutually catalyzing each other, the paper attempts to show why it is important to bring these approaches together for a more refined understanding of the controversial role these stone tools played in human evolution.

✉ Manjari Chakrabarty
manjari.chakraborty@visva-bharati.ac.in

[1] Department of Philosophy and Comparative Religion, Visva Bharati (Central University), Santiniketan, West Bengal 731235, India

Keywords Post-phenomenology · Material engagement theory · Embodiment relations · Non-neutrality · Quasi-transparency · Continuity thesis · Stone flaking · Prehistoric knapper · Oldowan technology

The domain of early hominin technology (i.e., lower Paleolithic stone tool making and tool using abilities) has received little scholarly attention in mainstream philosophy of technology.[1] This is despite the fact that the voluminous archeological record of stone tools shaped and used by *Homo habilis* or *Homo erectus* is widely regarded as the most enduring source of evidence for the initial emergence of some form of hominin cognition or cognitive behavior (see, e.g., Wynn and Coolidge 2016; Moore and Perston 2016). There is a considerable archeological literature on the cognitive dimensions of specific hominin technical activities (see, e.g., Malafouris 2008a; Malafouris and Renfrew 2010; Wynn 1993) such as stone knapping (e.g., De Beaune 2004; Nowell and Davidson 2010) or, more generally, stone tool making (e.g., Stout and Chaminade 2009; De la Torre 2011; Wynn 2009; Wynn and Coolidge 2016; Wynn and Coolidge 2017; Coolidge and Wynn 2017). These studies strengthen the archeological intuition that stone tools played a seminal role in the evolution of the early hominin mind or cognitive abilities. However, within archeology and the study of hominid evolution, stone tools are typically described as products of the hominin mind (or brain or innate cognitive capacities). Evidently, the causal arrow assumed in this standard perception is one way—from mind (or brain or cognitive capacities) to tools or artifacts[2] or material culture.

Reviewing the literature of several humanities and social science disciplines (e.g., cognitive science, psychology, philosophy of mind) from (roughly) the past three decades, one finds a number of interesting approaches to cognition that challenges this simplistic one-way-causal-arrow view and promotes a new way of thinking about the mind and its boundaries. Cognitive activities or processes are increasingly interpreted as not just something happening entirely inside our head about the world out there but as embodied, extended, and distributed processes (e.g., Clark 2007, 2008; Hutchins 1995, 2008). Clark (2007, 2008), for example, characterizes minds as systems that extend beyond the body of the human organism and include extra-somatic resources. In similar vein, Hutchins (1995, 2008) interprets the cognitive system as a distributed one that not only transcends the boundaries of the brain and body but includes objects, events, and other living beings in the setting in which human (and non-human) cognition takes place. The defenders of this beyond-the-body conception of the human mind or cognitive system place great emphasis on the critical role such extra-somatic environmental resources, e.g., tools or artifacts played in transforming and augmenting human cognitive capacities (see, e.g., Donald 2010; Hutchins 2001; Jeffares 2010a, b; Menary 2007; Sterelny 2010; Stotz 2010). Hence, the very idea that tools or artifacts are intimately tied to human cognitive abilities or processes is fast becoming an alternative within the cognitive sciences and a few allied disciplines. What this means for philosophy of technology, in particular, for the technology of archaic humans is

[1] A few notable exceptions are Preston (1998) and Ihde (2007).

[2] The terms "artifacts" and "tools," used interchangeably in this paper, stand for the tangible products of human activities (both physical and cognitive). They are manufactured or modified in response to some need, want, or desire to produce an intended result.

only beginning to be explored (see, e.g., Preston 1998; Ihde 2007). The present study intends to be a part of that exploration by considering the example of the making and use of prehistoric stone tools.

The objective of this paper is to explore the dynamic and intricate tool-mediated activities of the early hominins through the lens of Don Ihde's (1979, 1990, 2007, 2009, 2012) post-phenomenological theory of human-technology relations and Lambros Malafouris' (2008b, c, 2013, 2015, 2016) material engagement theory. The intricacies of human-artifact or cognition-material culture relations have been a source of curiosity and contemplation for both Ihde and Malafouris. More enlightening perhaps is to note that their research approaches share a distinctive emphasis on the inherently reciprocal nature of human-artifact or cognition-material culture interactions. Challenging the conventional one-way-causal-arrow view from cognition to material culture, both Ihde and Malafouris argue that tools or artifacts can and, in fact, do actively shape human cognition, human action, and human ways of being in and making sense of the world. Thus instead of positing that changes in the archeological record of stone tools are primarily the result of hominin cognitive transformations, Ihde's (1979, 1990) theory implicitly and Malafouris' (2013) theory explicitly suggest that early stone tool making activities had a critical impact on the initial development of the cognitive machinery of the prehistoric stone tool makers.

However, when it comes to the problem of explaining the agent's act of engaging with a tool, Ihde's (1979, 1990) post-phenomenological account differs subtly but decisively from Malafouris' material engagement theory. While Malafouris (2013) endeavors ambitiously to develop a narrative of radically or profoundly embodied agents essentially open to deep incorporation of new bodily, sensory, or cognitive structures, Ihde (1979, 1990) seems skeptical about the possibility of profound or radical embodiment and speaks instead about actively embodied agents capable of extending their bodily self-experience beyond the limits of the biological skin-bag body.[3] From the post-phenomenological perspective, a prehistoric knapper would thus be an active (biological) agent engaging with the surrounding environment by means of stone tools that function as direct extensions of the agent's body. In somewhat stark contrast, the material engagement theory (Malafouris 2013) construes the stone tools as genuine parts of, rather than products of, the emerging (hominin) cognitive processes that typically span the organismal boundaries and extend into extra-cranial space. Thus from Malafouris' standpoint, the prehistoric knapper-stone tool interactions are to be interpreted not as cases in which (intracranially localized) cognitive processes interact with non-cognitive (i.e., extracranial biological, chemical, or physical) structures but as cases of exclusively cognitive processes.

In spite of this basic difference in their research approaches, what is worth noting in both Ihde and Malafouris is an urge to shift our focus away from the constraining ontologies of early modern (philosophical) thinking to an inter-relational ontological framework (Ihde 2003, p. 20) or to a relational ontological domain or foundation (Malafouris 2013, p. 50). The present endeavor is directed toward highlighting the

[3] This transformation of human self-experience, as we shall see in section II, entails the possibilities of a certain extension (or amplification) of experience as well as a reduction in (or alteration of) experience and thereby thwarts the human yearning for profound embodiment (Ihde 1979, 1990).

key points where these two theories, regardless of their nuances, converge and look capable of mutually catalyzing each other. In the course of the present inquiry, those critical intersections will be revealed by an attempt to address the following question—is the proficient prehistoric stone tool maker (and user) an early example of a profoundly embodied (proto-human) agent or an actively embodied agent?

The present paper unfolds as follows. The first section consists of a brief overview of early hominin tool making and tool using activities. For, to understand the role played by the stone tools within the cognitive economy of the early *Homo*, which includes such species as *Homo habilis* and *Homo rudolfensis* (Jeffares 2010a, p. 507), it is very important to have an insight into the evolutionary context of the tools themselves. The second section attempts to explain the knapper-stone tool interactions as typical instances of "embodiment relations"—one of the three main kinds of human-artifact relations discussed by Ihde (1979, 1990)—and draw attention to the concepts of non-neutrality and quasi-transparency. The third section reconsiders the problem of knapper-stone tool relations from the perspective of material engagement theory (Malafouris 2013) to see if any fresh light can be thrown on the current theorizing about the possible understanding of tools as genuine extensions of our cognitive processes instead of our physiological abilities. This paper concludes by pointing out why it is important to bring the philosophical and archaeological, i.e., the post-phenomenological and the material engagement approaches together for a more refined understanding of the controversial role these stone tools played in the evolution of the genus *Homo*. If these prehistoric stone tools were not mere products or consequences of early hominin cognition as both Ihde and Malafouris—critics of the traditional one-way-causal-arrow view—argue, how possibly were they connected, in a philosophically important sense, to hominin brain and cognitive evolution?

1 Section I: Early Hominin Stone Tool Technology

The latest discovery of the earliest known stone tools at Lomekwi 3 (LOM 3) from West Turkana, Kenya (Lewis and Harmand 2016) raises new questions on the possible function of early stone tools, on the timing of the emergence of manual manipulative capabilities of early hominins and on the cognitive requirements for the emergence of stone tool behavior. The present section, however, focuses on the stone tool production known as the Oldowan (Leaky 1971) or mode 1 (Clark 1977) industrial complex and considers the tool making and tool using activities of the principal Oldowan tool maker—the early *Homo habilis* (Leaky 1971).[4] *Homo habilis* might not have been the first hominin to use tools,[5] but it seemed to be the first to make tools that were reusable and retained for future use (Jeffares 2010a, p. 509). Probably, *Homo habilis* was the first bipedal hominin to start, sometime between 2.00 and 2.4 million years ago, retaining and reusing tools—mostly sharp stone flakes and cobbles (see, e.g.,

[4] Whether it is appropriate to group all the African Plio-Pleistocene stone assemblages dated between 2.6 and 1.6 Myr into one techno-cultural Oldowan complex and to ignore all inter-site differences is debatable (for details see Delagnes and Roche 2005).

[5] Leakey's view has been questioned by contemporary scholars like Jeffares (2010a) who believes that *Homo habilis* definitely had tool using ancestors.

Coolidge and Wynn 2016)—to adapt to and survive in an increasingly heterogeneous, unstable environment.

Our knowledge of tool manufacture and use by other primates has much intensified in recent years (see, e.g., Ottoni 2015; Proffitt et al. 2016; Bruner and Iriki 2016). Bruner and Iriki (2016, p. 4), for instance, draw an interesting distinction between the tool-assisted foraging of some primates or birds and the tool-dependent[6] foraging of the human genus that indicates a new level of integration between brain, hand, and tool. Though the present study makes no such claim that the making and use of sharp-edged flakes is necessarily tied to the genus *Homo*, it might have been the case that the human genus introduced fundamental changes in the way the brain interacts with the environment two million years ago. A review of this early technology-based adaptive strategy of the *Homo habilis* is thus required to explore broader philosophical questions related to the cognitive, ecological, social conditions, and mechanisms fostering the emergence of stone tool making traditions.

The Oldowan stone tools include a range of core forms usually made of cobbles or chunks as for example, the flakes (whole flakes, split flakes, angular and other fragments struck from these cores), battered hammer-stones used to produce the flaking blows, and also flake fragments that have been later chipped along one or more edges. All these simple flaked and battered forms of Oldowan tools exhibit a breakage pattern known as *conchodial* fracture (resulting from high-impact percussion) and contrast sharply with the naturally broken stones found in the surrounding geological conditions. How these flaked-stone tools exactly fitted into the lives of their makers is not completely clear but this Oldowan technology had possibly developed in association with critical changes in diet and in biological form. As Schick and Toth (1993) point out, through stone tool making and use, these *Homo habilis* were able to expand their diet breadth and improve the quality of their diets that consequently facilitated their physical survival and reproductive success. It is thus crucial to our understanding of early hominin origins that we thoroughly investigate the multiple functions of these flaked-stone tools.

Present-day experimentation with percussion-induced flaked-stone technologies and ethno-archeological data from hunter-gatherer group suggest two possible reasons for the adoption of Oldowan technology. Firstly, the sharp-edged flakes were used for defleshing carcasses and creating chopping or scraping edges that can be used for making things like wooden digging sticks or spears and secondly, the cores were used for bone smashing and extraction of marrow (Schick and Toth 1993). More recent studies (see, e.g., Wynn et al. 2011) also attest to this possibility that Oldowan hominins used stone tools for butchery. The fragmentary animal bones found at several Oldowan sites along with stone tools exhibit cut marks made by stone flakes (Wynn et al. 2011, p. 189). One can also infer that these flaked-stone tools had offered the *Homo habilis* a unique way of adapting to new ecological conditions such as moving into places that had previously been the domain of carnivores. These early hominins with their relatively small canine teeth or flat cheek teeth were not biologically well equipped for such ecological niches (Toth 1987, p. 121).

[6] When the whole foraging process (including its cognitive parts) strictly relies on the body-tool interaction and its properties and relationships being generated only through that interaction, it is called tool-dependent foraging (Bruner and Iriki 2016, p. 4).

However, the question that concerns us most is: can these stone tools tell us anything about the cognitive abilities of these Oldowan tool makers that were not present in earlier hominins, *australopithecines* for example, or in modern non-human primates, including the highly intelligent apes? To understand the cognitive prerequisites of early stone tool technology, we need to have an insight into the manufacturing process of these tools. Oldowan flake production consists not simply of actual flaking techniques (including core examination, target selection, core positioning, hammer-stone grip selection, and accurate percussion) but also of acquiring raw materials of appropriate size, shape, and composition (Jeffares 2010b, p. 165; Stout 2011, p. 1051). At this point, one should be aware of what is often called the problem of minimum necessary competence—the problem that archeologists can assess only the minimal abilities required for producing a particular pattern of tools or artifacts (Wynn and McGrew 1989, p. 384). For the purposes of our present investigation, this means explaining the least complicated procedure that would suffice for accomplishing the Oldowan stone flaking task.

Increasingly sophisticated reconstructions of hominin activities associated with stone tools in detailed ecological and social settings are available today (see, e.g., Toth 1985, 1987; Toth and Schick 2009; Stout 2002, 2011). In the simplest kind of stone tool making, the knapper strikes a cobble with another usually harder stone often called a hammer. This basic action produces two potentially useful products—a smaller, thin piece called a flake having a sharp edge and a relatively larger piece called a core from which the flake was removed. The large piece now has a few sharper and potentially useful edges than it did before. To flake stone competently one needs to constantly search for acute angles on core edges from which to detach flakes. Even this simple hammering technique requires that the knapper direct blows toward particular locations on the target core.

Upon careful scrutiny, the stone-flaking process appears to depend on two features. Firstly, it depends on the control of the pattern of application of forces to a stone. A carefully controlled, sharp blow from the hammer to the core is required to initiate fracture. The knapper must control actions directed at a relatively small spatial field and must place a blow over an acutely angled edge. Thus strength in delivering blows and precision in the placement of blows are both necessary. Secondly, the process of stone flaking depends on the mechanics of stone-fracture (i.e., on the internal properties of the stone) when the force is applied. The failure to apply force in the right direction does not usually bring the required changes to the stone even when the raw material has the required properties. Similarly, applying force in the correct way but to unsuitable raw materials may not produce the intended result.

Quite predictably, certain features of human anatomy appeared to have evolved as an adaptation to stone flaking, that is, to the intrinsic and extrinsic forces associated with the grasp and manipulation of stones in hammering. The most salient of these features can be noted in the human hand. The long thumbs relative to fingers, broad fingertip pads, and a set of features in the central palm make the human hand more stable compared to those of apes (see, e.g., Marzke 1996; 1997). Many such features have been identified by archeologists on two million-year-old hominin fossils. Nevertheless, it would be philosophically more interesting to find out whether or not these stone tools are indicative of specialized cognitive processes or operational skills of a kind that the earlier *australopithecines* did not seem to have 4.5 million years ago. Detailed accounts

of some specific and dedicated cognitive module to have evolved in support of early stone flaking are not easily accessible. One might here refer to the study of Keller and Keller (1996) on how people learn tool use by observation, replication, and repetition. But Keller and Keller's (1996) investigation is often criticized for not taking the spatial-cognitive component into account that seems crucial for even the simplest kind of stone flaking. Wynn and McGrew (1989, p. 387), for instance, identify a set of three spatial concepts, namely proximity, boundary, and order that are required as a minimum for the making of Oldowan tools.

Several archeologists (e.g., Wynn 2002; Stout and Chaminade 2007) today describe Oldowan stone tool making as a quite complex sensorimotor task that basically involves visuo-motor coordination and evaluation of core morphology (e.g., angles, surfaces) to direct forceful blows to appropriate targets. Even placing blows in more or less the same place (i.e., in proximity) does require some coordination of motor patterns (Wynn and McGrew 1989, p. 387). Although such visuo-motor skills are sometimes dismissed as trivial or primitive compared to abstract conceptualization, archeological data (e.g., Stout and Chaminade 2007) indicate that huge portions of the modern human brain (including areas like the cerebellum, superior parietal lobule, and premotor cortices) are involved in such skillful activities as evident in prehistoric stone flaking. In view of these recent archeological facts, it would not be too unreasonable to argue that such sophisticated visuo-motor skills (that can take years of dedicated practice to acquire) are as reflective of distinctive human cognitive abilities as abilities like abstract conceptualization or language use.

Another interesting alternative for our present purposes would be to consider the results of the experiments with Kanzi—a bonobo quite famous for his ability to understand spoken English and to use signs. Archeologists' experiments (see, e.g., Toth et al. 1993, 2006) with Kanzi show that he was able to learn how to fracture stones to make sharp cutting edges by observing a human knapper. Clearly, the most basic requirement for stone flaking, namely using a hammer to remove a flake, was within the abilities of modern apes. However, even after 10 years of practice in a supportive social context, Kanzi could not learn Oldowan knapper's technique of searching for acute angles on cores from which to detach flakes efficiently or that of using flake scars on one flake of a core as striking platforms for removing flakes from another face. Kanzi's failure cannot be easily attributed to his lack of adequate manual dexterity because he was quite able to tie shoe laces and undo buttons (Mithen 1998 [1996], p. 108).

Bryne's (2004) study on what cognitive similarities and differences there might be in the manual skills of apes and those of early *Homo habilis* makes practically the same point. To detach the type of flakes found in the site of Olduvai Gorge, Bryne (2004) states, one requires to search for acute angles on the nodules, to select so-called striking platforms, and to employ good hand-eye coordination to strike the nodule with the proper force, at the proper point of percussion, in the right direction. Though Bryne's (2004) research finds a substantial overlap between apes' manual skills and those required for stone flaking, he notices that a key feature, viz., the accurate aiming of powerful blows, which seems necessary for skillful stone flaking, is missing from the ape repertoire.

Some scholars (see, e.g., Mithen and Parsons 2008; Stout 2002, 2011) prefer to see these basic, well-controlled stone flaking techniques used by the prehistoric knappers as indicative of a significant development of perceptual-cognitive abilities and refined motor skills. But one might still be curious to inquire whether these differences between

the tool making technique of Oldowan hominins and modern apes necessarily point to a difference in cognitive capacities or are primarily due to ecological and dietary changes. Archeologist Wynn (2002) has reservations about suggesting any obvious growth in the cognitive or intellectual abilities of the early *Homo habilis* (beyond that of the African apes) in their manufacture and use of Oldowan tools. Even the spatial concepts needed to make Oldowan tools, Wynn and McGrew (1989, 388) argue, can all be found in the repertoire of living apes. Though Wynn and his allies (Wynn and McGrew 1989; Wynn 2002) see no clear sign of a major leap in the cognitive abilities of Oldowan tool makers, more recent studies conducted by archeologists Toth and Schick (2009) on ape and hominin tool use suggest a different conclusion. It is true Oldowan stone tools do not show any clear sign of deliberate or stylistic design but the cognitive abilities required for the basic flake removal technique of Oldowan knappers look qualitatively different from that of their *australopithecine* ancestors or of modern apes owing to the reasons stated below.

Archeological data indicate that Oldowan hominins probably had the ability to identify an error (e.g., a percussion mistake) in a planned sequence, to figure out how to work around this and to change the working core for continual removing of flakes (Toth and Schick 2009).

Moreover, from the analysis of reconstructed cores, it seems evident that Oldowan raw materials had been tested at the source, selected stone resources had been transported for initial flaking at a second location, and then selected flaking-products had been transported for use at a third location (Toth and Schick 2009). Even Wynn et al.'s (2011) recent and more detailed research on tool transport at the newly excavated sites at Gona, Koobi Fora, Lokalalei, and Kanjera confirms that what differentiates Oldowan hominins from modern apes is their regular and long-distance transport of cobbles of various raw material and the body parts of animals (Wynn et al. 2011, p. 195). Accumulating archeological facts are ever more supportive of the hypothesis that Oldowan knappers had a more critical understanding of the principles and mechanics of tool making than what modern apes generally exhibit during their tool use training. That Oldowan hominins did prefer particular raw materials and their choices reflected not only ease of flaking but also durability has now become an established fact (Wynn et al. 2011, p. 189). Considering these latest archeological findings, one might reasonably interpret Oldowan knappers' awareness of raw material quality or their forethought in multiple aspects of the tool manufacture and use as early signs of the emergence of some form of cognitive-behavioral abilities or cognitive processes not possessed by the apes.

Another interesting clue for some kind of connection between stone tool manufacture and the development of hominin cognitive capacities can be found in the relatively old but insightful hypothesis of Washburn (1978). Washburn's (1978) hypothesis states that technological progression from no stone tools to simple Oldowan stone tools to skillfully shaped and increasingly refined Acheulean bifacial cutting tools is correlated with the doubling or, as Stout (2008) more recently suggests, nearly tripling of hominin brain size. If this hypothesis is correct, the brains should not only have expanded in size but must also have grown more complex. Though the fossil record cannot provide any conclusive evidence for evolutionary changes in gross neural anatomy, some recent functional magnetic resonance imaging (fMRI) evidence (see, e.g., Orban and Caruana 2014) correlates the presence of a new neural apparatus located in left anterior

supramarginal gyrus (aSMG)—a region of the brain most likely involved in the execution of tool actions—with the emergence of *Homo habilis* or *Homo erectus*. It is the (roughly) parallel occurrence of these two most striking trends in hominid evolution—the growing sophistication of stone tools over hundreds of thousands of years and the nearly three-fold increase in hominin brain size accompanied by increasing neural resources—that brings forth the key problem for the present investigation: were these prehistoric flaked-stone tools, other than being (as assumed in the one-way-causal-arrow view) mere products or consequences of hominin cognitive processes, connected in any other important sense to hominin brain and cognitive evolution?

2 Section II: Knapper-Stone Tool Relations as Examples of Embodiment Relations

Ihde's (1979, 1990) post-phenomenological account of different types of human-artifact, or what he calls human-technology relations, namely embodiment relations, hermeneutic relations, alterity relations, and background relations, is arguably the most appreciated one that currently exists. He (Ihde 1979, 1990) offers detailed illustrations of the various ways in which I-as-body (i.e., the biological agent) interact with the environment by means of tools or artifacts. The prehistoric knapper-stone tool interactions may be characterized as an instance of what he (Ihde 1990, p.72) refers to as embodiment relations. In embodiment relations, the tool (or artifact), in terms of both spatial location and action, occupies the "position of mediation" between the biological agent and the environment the agent engages with (Ihde 1990, p. 73).

Ihde's post-phenomenological analysis of human-artifact relations in general and embodiment relations in particular is based on an "inter-relational" and "non-subjectivist" (Ihde 2003, 2009) ontological framework. What Ihde (2003, pp. 9–12) understands by "inter-relationality" is that the human experiencer, i.e., the biological agent, relates to the environment in such a way that both are transformed within this relationality. The environment is acted upon not merely through the movements of the agent's own body but also through the tool that the agent's body is engaging with and that is controlling and redirecting the agent's activity or behavior. The very inclusion of tools or artifacts brings in some difference into this relationality because changes in the environment necessarily correlate with changes in the human experiencer of the environment.

What is more, Ihde's post-phenomenology replaces the notion of subjectivity by the notion of embodiment. The notion of subjectivity, Ihde (2003, pp. 9–11) argues, reflects the early modern idea of the epistemological subject (or self) as enclosed "inside the (camera) box." The subject can see or know only representations or images of external reality (*media res*) projected into the (camera) box but cannot directly experience external reality (*media res*) beyond the (camera) box. This very notion of subjectivity thus carries with it an in-the-box implication which cannot be escaped as long as we use the old terminology (Ihde 2003, p. 11). If we go with this early modern vision of "inside the (camera) box" subject whose mind is a special realm populated by internal models and representations, we would be compelled to focus exclusively on the restricted space of the inner mental operations sealed off from the outer world. In that case, how much can we speculate on the cognitive skills or

behavior of the prehistoric tool maker or on the transformative function of the tools will be open to question.

Challenging this "in-the-box" central-controller notion of the subject artificially detached from the wider, outer world Ihde's (2003, pp. 9–11) post-Cartesian philosophical alternative draws attention to the centrality of our lived experience of everyday engagement with technological artifacts. The central question raised by Ihde may be stated as follows: what it is like for a biological agent to experience such mediating technologies or to experience their transformational effects (which arise due to the amplification and simultaneous reduction of the possibilities for action through technological means). To understand Ihde's postphenomenological position, let us take note of some distinctive features of embodiment relations. Embodiment relations entail experienced uses of tools or artifacts which co-enable our experience but are themselves not, at least primarily, in the focus of our experience. To borrow an example from Ihde (1990), when I put on my spectacles, they are in a position of mediation, between me and the world: I-spectacles-world. The referent of perception, that toward which my sight is directed, is on the other side of my spectacles. However, with time and repeated use, my spectacles despite being in a position of mediation become part of the way I ordinarily experience my world, that is, they are taken into my own perceptual-bodily self-experience: (I-spectacles) → world. Notably, the juncture (I-spectacles) → world is brought close because as a means of experience my spectacles gradually withdraw and are barely noticed by me. When my spectacles that mediate me to the world acquire a certain degree of transparency, I actively embody the eyeglass technology.[7] This transparency or withdrawal, Ihde (1990, p. 73) points out, is in effect a material condition for embodiment relations. In embodiment relations, artifacts become maximally transparent in the sense that they themselves do not become objectified or thematic but are taken into our experiencing of the world.

Quite interestingly, this withdrawal or transparency has an enigmatic character and is never total (Ihde 1990). I do experience the world through my spectacles but what is experienced is in some ways always transformed—I do not experience the world through the spectacles in exactly the same way that I experience the world without them. The use of spectacles necessarily transforms my ordinary "in the flesh" (Ihde 1979, p. 8) experience. For instance, I may have an inexplicit sense of pressure of the spectacles on my nose or ears while I experience a much clearer vision of the world through them. While some features of the experienced environment are amplified, others are reduced. Thus, my experience through the spectacles, or generally speaking, any tool-mediated experience is necessarily a transformed experience. An agent does not experience the world through the tools in exactly the same way that she experiences the world without them. This transformation contains the possibilities of a certain extension (or amplification) of experience as well as a reduction in experience. In extending bodily capacities, artifacts transform them, however subtly, however minimally. For that reason, tools or artifacts, Ihde (1979, 1990) convincingly argues, are not neutral intermediaries, but mediators—they actively mediate human-world relations or agent-environment interactions and have the potential to transform human experience, human actions in unanticipated or unintended ways. On Ihde's view, there is clearly no prospect for total or pure transparency and by implication, for profound embodiment as human interaction with non-neutral artifacts

[7] Beginners of course cannot experience this withdrawal or transparency of the tool.

is necessarily tied to certain transformational effects having a crucial magnification-reduction structure. Pure transparency is an ideal limit as tools never completely withdraw but always leave a vestigial presence (Ihde 1979, p. 72).

Two important post-phenomenological points are to be noted here. Firstly, experience as understood by Ihde is an affair of the dynamic interactions between a living organism and its physical and social environment. In sharp contrast to the subject in a *camera*-body-box, the engaged (biological) agent as a body-in-action is already outside itself in the world (Ihde 2003, p. 12). Secondly, tools or artifacts are taken into human experience through embodiment relations and as embodied beings our particularly structured body shapes our actions, experience, and knowledge in a particular way. These key insights of Ihde make the very act of engaging with a tool important in itself and also make room for developing a post-phenomenological account of knapper-stone tool interactions. Let us try to see how Oldowan hominins possibly had engaged with their flaked-stone tools in light of Ihde's interpretation of embodiment relations.

Ihde's (1979, 1990) analysis of embodiment relations is based on the idea that tools or artifacts directly extend the bodily capacities of the embodied agent. Although some recent critics (see, e.g., Woelert 2014) point to the limiting nature of Ihde's interpretation, the very idea of tools or artifacts being bodily extensions applies perfectly and meaningfully to the manual use of flaked-stone tools by the prehistoric knappers. In manual forms of tool use, a human (or a proto-human) agent employs an exosomatic environmental object to change more efficiently the form, position, or condition of another object in such a way that the agent's hands and arms guide the technical process and also provide power to the process (Beck 1980, p. 10).[8] Woelert (2014) refers to this form of technical activity as "tool use in direct motor function" and highlights the specific embodied and technical dynamics that are involved in such use. Tool use in direct motor function depends on the direct transmission of muscular power to an external tool where the tool directly extends the movement performed by the hands and arms, i.e., by the agent's body. Thus the agent's own motor action and the tool's technical action remain closely aligned to their respective direction. Flaked-stones or wooden sticks, capable of directly extending both the scope and the force of bodily movements, are typical examples of tools that are used in direct motor function. A wooden stick, for example, extends the technical reach of an agent's limbs, while a flaked-stone (an Oldowan hammer for example) is capable of exerting a concentrated force on target objects that could not possibly be achieved by bodily means alone. Now simultaneous with this amplificatory dimension, there is also a reductive dimension of mediating technologies that Ihde has drawn our attention to.

To continue with our example of the manual use of tools, the "magnificational gain" (Ihde 1979, p. 75), i.e., the direct extension of the bodily movements or bodily capacities, is necessarily accompanied by a noticeable reductive transformation of the magnificational capacity of the tool. To explain, the mediating function of the tool entails a significant decrease in the technical efficacy of the agent's own bodily movements in comparison to such cases or activities where the agent's hands directly function as tools.

[8] There is a wide array of technical actions in which the hands and arms play an important controlling role, as in using a computer key board. However, these technical actions do not qualify as manual forms of tool use because the movements of the human body play a peripheral, non-essential role with regard to the actual technical process and the forces involved (see Woelert 2014).

The cause of this decrease lies in the fact that in all forms of manual tool use, the hand of the tool user surrenders its own immediate technical function to the external tool. What is more, it is precisely this surrendering of the technical function of the agent-body that provides the tool user with a range of new, more effective ways of materially engaging with the environment (Woelert 2014). As archeological data verify Oldowan flaked-stone tools had offered *Homo habilis* a new means of increasing their diet breadth and of improving the quality of diets that consequently facilitated their physical survival in an increasingly heterogeneous environment. Without a thorough analysis of (Oldowan) knapper-stone tool relations, this dramatic magnificational or amplificational (Ihde 1979, p. 53) dimension of mediating technologies accompanied by its simultaneous reductivity is not easy to understand.

To appreciate more fully Ihde's observation regarding the non-neutrality or mediating capacities of tools, we need to focus on the two critical interfaces that are in play in his description of embodiment relations, viz., the agent-tool interface (e.g., where the agent engages with the tool) and the (agent-tool) → world interface (e.g., where the agent + tool engages with the world existing outside the agent's physical boundaries). The agent-tool relations transform, in quite definite ways, the experiential or "knowledge gathering" situation (Ihde 1979, p. 68) from any similar situation of an agent without a tool. Our extension of bodily capacities always involves some changes in our bodily, sensorimotor experience that defines the way we make sense of the world and of ourselves. Thus our involvement or engagement with tools changes to a great extent who or what we are. Secondly, although subtle to note, when the agent-tool pair engages with the world, it has an even more dramatic impact on the existential situation as a brand new problem-solving or analytical unit, viz., a new "(extended agent) → world" circuit (e.g., knapper + stone tool → world) comes into being that is not effectively reducible to the agent. The fundamental relational unit of the "agent + tool" confronts the world in a markedly different way than the non-relational unit of "the agent without the tool." One may recall here how *Homo habilis* armed with their flaked-stone tools adapted to and survived in an ever-changing environment that their ancestors without tools possibly could not. Without a scrutiny of the symbioses between the "agent" and "tool" and that between the "extended agent" and the "world," the non-neutrality or mediating capacities of the tools and the consequent transformations of the agent's experience cannot be fully explained.

What one might be interested in asking Ihde is—can we see these flaked-stone tools as extensions of prehistoric knapper's cognitive capabilities in addition to (or instead of) seeing them as extensions of their bodily or physiological abilities? Or, to revert to our original problem, what roles did these stone tools possibly play in the evolution of the hominin mind or cognitive system? These questions will be addressed in the concluding section.

3 Section III: Knapper-Stone Tool Relations as Examples of Purely Cognitive Processes

Let us now examine the phenomenon of prehistoric stone tool making and use from the perspective of Malafouris' material engagement theory—the theory of the constitutive intertwining of cognition with material culture. Our aim is to see whether or not

Malafouris' theory throws any fresh light on our critical-philosophical understanding of knapper-stone tool (or cognition-material culture) interactions. The main issues to be discussed in this section are as follows: is prehistoric tool making and use a matter of partially cognitive (i.e., intracranially localized) processes interacting with non-cognitive (i.e., extracranial biological, chemical, or physical) processes? Or are such knapper-stone tool (or cognition-material culture) relations to be seen as entirely cognitive processes that transcend the cranial or organismal boundary and extend into extracranial space?

We commonly assume that tool manufacture and use is a physical act—it is something we do. When it comes to understanding its cognitive (or mental) dimension, we tend to believe that this is something happening within us, possibly inside our heads. Thus we perceive the cognitive and the physical components of every act of tool making as two distinct phenomena happening at slightly different times in different locations with the former necessarily causing the latter (Malafouris 2016, p. 71). Evidently, a deeply entrenched Cartesian metaphysical assumption of the discontinuity between what is inside the mind and what is outside of it continues to affect our thinking, blind us to any alternative conceptualization, and, most importantly, leads us to undervalue what Malafouris (2013, p. 57) refers to as the "explanatory and transformative power" of material culture.

The originality and freshness of Malafouris' material engagement approach toward prehistoric stone tool manufacture lies in the way he draws attention to the philosophical significance of the process of knapping (Malafouris 2013, pp. 161–162). In addition to providing a lot of archeological information about the evolution of hominin skill or technological practice, the knapping-process, Malafouris (2013, pp. 162) points out, sparks certain intriguing philosophical questions relating to the (ontological) distinction between the knapper's mind and the stone tool—questions that the archeologists in the context of stone tool making seldom pose. Material culture is widely interpreted by the archeologists as the product of human (or hominin) cognitive behavior. Cognitive processes (construed more often as essentially brain-bound) come first and the archeologically visible cultural products come second. From this inherently dualistic archeological position, a stone tool can only be seen as an external representation of some intracranial cognitive processes or as an epiphenomenal cognitive residue left by the operational sequence of the knapping-process (Malafouris 2013). The archeologists, therefore, are left with no other alternative but to use those secondary, residual (cognitive) traces of the knapping-process for drawing inferences about the cognitive behavior of the early hominins.

In sharp contrast to this traditional view of evidence Malafouris' (2013, p. 164) material engagement theory characterizes knapping as an act of thought or a cognitive act (instead of a physical or bodily act) and interprets these early flaked-stone tools as participating in the knapper's cognitive realm per se, i.e., as cognitive prostheses or artifacts capable of transforming the cognitive machinery of our hominin ancestors. For construing knapping as a cognitive act, Malafouris (2013) places the problem of cognition-material culture or knapper-stone tool interactions upon a relational ontological foundation different from the Cartesian one. The principal contention of Malafouris' (2013, p. 77) theory is that human cognition and material culture, more than merely being causally linked, are constitutively interdependent. What Malafouris means by saying that cognition and material culture are co-constituted in situated action is that our multiple ways of thinking or cognitive processes are genuinely constituted

by (and not merely causally dependent upon) extracranial processes and elements in our surrounding environment (Malafouris 2015, p. 366). Since the sort of stuff that constitutes human cognitive processes can be equally found located within and outside of the brain, human cognition, Malafouris (2013, 85) claims, has no fixed ontological location. Our critical focus, therefore, should shift from the alleged distinction between the mind and matter (or the inner and outer) toward developing relational ways of thinking about mutual interactions among brain, body, and world.

Conventional archeological accounts of stone tool manufacture usually connect cognitive activity either with internal planning or with some neuro-physiological activities. Such accounts invariably presuppose the image of a central self-conscious agent or executive controller who orders, guides, and controls the movement of the hands and who, in some sense, is using the body to execute and externalize a preconceived mental plan through the stone. The material engagement approach demands a replacement of this inherently dualistic vision of "projective mentality" with an inherently dynamic vision of "participatory mentality" (Malafouris 2016, p. 78). The vision of "participatory mentality" has the implication that a prehistoric stone tool is not a mere output of certain brain-bound (hominin) cognitive processes but it constitutes (or participates in) at least some of the cognitive processes involved in the process of knapping or stone flaking. Our bodily movements, skillful embodied actions, and prosthetic gestures do not merely execute our cognitive processes or mediate neural activation pattern but often generate and constitute such processes (Malafouris 2016).

Malafouris' (2013, pp. 50–53) analysis of the material engagement approach relies mainly on three mutually supporting working hypotheses, namely the hypothesis of the extended mind (which explores the constitutive intertwining of cognition with material culture), the hypothesis of enactive signification (which explores the nature of the material sign not as a representational mechanism but as a semiotic conflation and cohabitation through matter that enacts and brings forth the world), and the hypothesis of material agency (which explores agency not as a human property but as the emergent product of situated activity). However, a crucial, though not usually noted in the literature, feature of Malafouris' theory is its striking similarities with Menary's (2009) thesis of cognitive continuity. Challenging the radical duality or discontinuity between the mind (*res cogitans*) and the world (*res extensa*) Menary's (2009, pp. 31–32) continuity thesis suggests that our cognitive capacities are not intrinsically different from our biological or physical capacities. From an evolutionary perspective, what we commonly consider as bodily or physiological activities, such as the act of stone flaking, or more generally speaking, our abilities for manipulating the environment, are basically and minimally cognitive processes (Menary 2009). This close resemblance between Malafouris' portrayal of knapping as a cognitive act and Menary's continuity thesis is too important to ignore for our present study.

One might argue against this radical hypothesis of the constitutive intertwining of cognition and material culture that Malafouris erroneously takes the mere epiphenomenal or causal influence of material culture (let us say, the Linear B tablet) on human cognition (for instance, the Mycenaean memory system) for something more substantial. That the Mycenaean is interacting with or using a linear B tablet to store information outside the head seems quite understandable but Malafouris' claim is a much stronger one. To say, echoing Malafouris (2013), that a clay tablet actually participates in the cognitive processes responsible for how the Mycenaean remembers, amounts to

committing what is often described as the "coupling constitution fallacy" (Adams and Aizawa 2009)—the fallacy of conflating the ontologically important distinction between causation and constitution, or between mere interaction and participation.

Such critical concerns, Malafouris (2013, pp. 80–81) believes, originate mainly from the classical computational view still embedded in current philosophical thinking that defines cognition as beginning with an input to the brain and ends with an output from the brain. If human cognitive processing is understood as essentially brain-bound, then what archeologists excavate are nothing more than mere residues of past cognitive behavior. Malafouris (2013) openly challenges this classical computational view and the related assumptions about the intracranial boundaries of human (or hominin) cognition. Challenging the traditional-computational portrayal of the human brain as a rule-governed information processing system (and the mind as a program managed by the brain), Malafouris' (2013) theory describes the brain as an element of a larger system that incorporates material culture. What goes on strictly inside the head (e.g., a neuro-physiological activity) can only count as constituents or participants in a broader cognitive process involving a dynamic relationship among brains, bodies, and things or material culture. In another place, Malafouris (2015, p. 366) depicts human cognitive processing as a "hylonoetic" field—a mindscape extending into the extra-organismic environment and material culture—the physical location and ontology of which remains an open question. We may now begin to see why the old ideas of the brain as the central executive controller and the hand as an instrument of the brain no longer look very promising. Malafouris' material engagement approach tempts us to embrace the possibility that it might well be the case that actually our embodied activities control our brains and shape the way we think and act. Tools and the embodied activity that their use and manufacture affords cannot simply be the products of cognitive or mental or neuro-physiological operations but are central to the organization and constitution of such operations (Malafouris 2016, p. 76).

Examining the case of the Acheulean hand axe Malafouris (2013, p. 169) shows how stone tool making can be seen as a unique and archeologically visible case of an integrative cognitive system whose constitutive parts are spread beyond skin and skull. What he has written on the manufacturing of the Acheulean hand axe could be profitably extended to the case of Oldowan stone flaking as well. Almost all major accounts of the Acheulean hand axe problem, in spite of their internal differences, implicitly conceive knapping as some sort of unidirectional causal operation between the active mind and the passive stone. To put it in other words, knapping is commonly described as a sequential process in which the knapper's cognitive states (e.g., prior intentions) formed inside the knapper's head (in advance of the action itself) causes the physical movement or act of the agent that eventually produces the stone tool. The ontological commitment implicit in this wide-spread archeological perception is that knapping is an intermediate physical-behavioral process between the inner cognitive (or neurological) states causing such behavior and the stone tools that are the external products of those brain-bound cognitive states. This (at least partially) explains why the status of tools or material culture in standard archeological narrative is derivative and merely epiphenomenal.

Contrary to what most archeologists are inclined to believe, Malafouris (2013, p. 173) argues that the directed action of stone knapping is not caused by the knapper's cognitive states (e.g., prior intentions) but actually brings about such states. The

decisions about where to place the next blow and how much force to use are neither taken by the knapper in isolation nor are they processed internally prior to the action. The best angles for flake removal are not identified or anticipated in the knapper's head before the act. The accurate aiming of a powerful blow is not pre-planned but is often discovered in action. Every stroke prepares the platform for the next and reveals something new about the stone's features. Successive flake removals (in skilled flake production) produce viable angles and flaking surfaces which may be used effectively. One of the first things that the knapper must learn comes from the "feeling" or "tactility" of the stone, i.e., from sensing the material qualities of the stone (Malafouris 2013, p. 173). This sort of engaging with the stone, to be precise, the feeling of its weight or the sensing of its sharpness at the edge or the smoothness of its surface, constitutes a cognitive skill that is very crucial in the context of stone tool manufacture and use.

Malafouris (2013), however, does not deny that knapping as a form of embodied manual skill is connected with or leads to certain patterns of neural activation (see Stout et al. 2008). What he wants us to avoid is the image of a central neural engine that uses the stone and the human body only to materialize and externalize pre-formed ideas or plans. In the hand of the knapper, the stone is not simply an inert blank surface upon which the knapper's pre-formed ideas or plans are imposed. When it comes to stone tool making and use, Malafouris (2013) argues, the brain does not act as the executive controller for embodied activities rather it itself is controlled by such activities. It is the stone that guides the grip, the grip molds the hand, the hand shapes the tool, and engagement with the tool affects the agent's cognitive processes. If any formative thinking is taking place during the knapping process, it is to be sought at the knapper-stone tool interface, i.e., in the interactive space between the affordances of the raw material (Gibson 1977) and the sensorimotor properties of the hominin hand (not in some sort of fixed idea stored inside the knapper's head). For present purposes, suffice it to say that a good deal of some early form of prehistoric thought or cognitive processes possibly emerged in dynamic interactions of the hominin brain and body with the world. Those dynamic interactions were not the consequences of any inner underlying cognitive processes rather they constitute the very cognitive processes themselves.

We may now see the rationale behind Malafouris' attempt to provide a fresh philosophical-archeological perspective on our present and past ways of thinking that are actually constituted by and not merely causally dependent upon extracranial bodily processes and exosomatic tools or artifacts. Most of our thinking, as Malafouris (2016, p. 297) sums up in one of his recent writings, are thinking with, through, and about things. There is a question still lurking for the present inquiry: can material engagement theory plausibly construe tools or artifacts as parts of our extended and hybrid cognitive system without incorporating Menary's (2009) cognitive continuity thesis? This question will be considered in the following section.

4 Section III: Concluding Thoughts

We do not take this paper to critically assess either the post-phenomenological or the material engagement approach. Our main concern is to find out how these research approaches can mutually benefit each other. To begin with, it seems quite clear by now

that the early modern vision of ontological boundaries or of the concomitant sharp division between the "inside the (camera) box" subject or self (Ihde 2003, pp. 9–11) and the world outside the subject's physical boundaries accessible only via a variety of sensory channels is not comprehensive enough to explain the profound complexities of the prehistoric knapper-stone tool relations we investigate in this paper. Considering the limitations of this centuries old ontological framework, the post-phenomenological and the material engagement theories focus on how environmental resources can transform our bodily or cognitive capacities. One might here find a clue as to why the phenomenon of prehistoric stone tool making and use is not incidental but quite essential to our understanding of our evolutionary past.

The key question for the present study, as noted before, is—were the stone tools connected in any important sense to hominin brain and cognitive evolution apart from being, as is often assumed, mere consequences of early hominin cognitive processes? Malafouris' answer is that prehistoric flaked-stone tools were genuine constituents or components of the emerging cognitive processes of the ancient (hominin) knappers. Although a flaked-stone tool as a tangible three-dimensional product is, in an obvious sense, external to an Oldowan knapper's brain, it can, nevertheless, be construed as (partially) constituting the (cognitive) act or process of knapping that emerge involving dynamic coordination of the so-called internal (i.e., inside the head) and external resources or structures. Interpreting tools or artifacts as genuine constituents of the extended cognitive system (that spans the organismal boundaries and extends into the world), Malafouris' material engagement theory performs a crucial three-fold task. Firstly, it challenges the conventional one-way-causal-arrow view and resists us from falling into typical, metaphysical errors related to the long-standing mind-world dichotomy; secondly, it draws archeological-philosophical attention to the transformative and explanatory power, i.e., to the essential non-neutrality (Ihde 1979) of material culture; and thirdly, allowing more access into the components of the human (or hominin) cognitive system than what other archeological approaches approve of Malafouris' theory paves the way for the archeologists to excavate (i.e., to directly access) past minds.

The prime philosophical reason behind Malafouris' interpretation of tools as constituents of human (or hominin) cognitive processes lies in his dissatisfaction with the conventional archeological portrayal of material culture as mere epiphenomenal residue of in-the-head cognitive processes. From the traditional archeological standpoint, the Oldowan flaked-stone tools would simply be passive external aids for de-fleshing carcasses or for bone smashing and extraction of marrow without any real cognitive bearing. The alternative approach to cognitive extension appears to be an illuminating one for Malafouris because mainstream archeological narratives tend to ignore the transformative or explanatory power of material culture and also rule out the possibility of gaining direct access to past minds. It seems presumably incontestable that if, as Malafouris argues, tools themselves are understood as genuine cognitive extensions or prostheses, then the standard interpretation of material culture as mere leftovers of our cognitive processes (as implicit in the one-way-causal-arrow view) can be questioned. What seems more intriguing is the implication Malafouris' (2013) material engagement theory has for critical-philosophical reflections on early hominin technology. The flaked-stone tools, seen through the lens of Malafouris' theory, appear not as passive receptacles of Oldowan knappers' cognitive (or thought) contents but as real examples

of how prehistoric thinking possibly took shape or how hominin cognitive capabilities possibly emerged through the prehistoric tool makers' incessant interaction with their environment.

Malafouris' effort in drawing critical attention to the transformative potential, i.e., to the non-neutrality of material culture, is indeed praiseworthy. However, the very structure of such transformations essentially tied to cognition-material culture relations and their philosophical implications are more clearly noticeable in Ihde's post-phenomenological account. Whereas Ihde's post-phenomenological analysis involves two critical interfaces, Malafouris' theory describes cognition-material culture relations as seamless and continuous cognitive processes (criss-crossing the boundaries of skin and skull and extending to the world) revealing no such pronounced interfaces. He (Malafouris 2013, p. 245) comes closest to Ihde when he brings up the issue of mediational effects at the end of his 2013 book and mentions that material culture as mediational means not only change and reconfigure the relationships between the agent and the tool (or artifact) she engages with but also drastically transform the relations between the extended agent and the world. His (Malafouris 2013, p. 245) brief description of the mediational effects could have been further illuminated with Ihde's (1979, pp. 74–77) post-phenomenological insights on the aspects of quasi-transparency and non-neutrality.

When tools or artifacts are functioning well, Ihde (1979, 1990) argues, they become quasi-transparent in the tool-use situation. This quasi-transparency of a tool is a functional condition (though not a sufficient one) for the attainment of new goals, say the attainment of an improved vision or the accessing of food by de-fleshing the carcasses. Crucial is to see that the ideal of pure transparency is a conceptual matter, whereas the fact of quasi-transparency relates directly to an existential situation. These two are not to be confused. Just as there is confusion between the conceptual and the existential with regard to transparency, there is an equivalent confusion with regard to the transformational effects relating to tool use (Ihde 1979, pp. 72–73).Transparency alone is not sufficient for a tool's being a condition of the possibility of achieving new goals, some transformational property is also required. That is, some actual difference between, say, a direct perceptual situation and a tool-mediated perceptual situation must obtain for a tool's being a condition of the possibility of meeting new targets. The transformational capacity of tools in use, as noted in the first section, entails a two-sided phenomenon: simultaneous and co-extensive with every magnificational capacity there is a reductive effect. This magnification-reduction is a structural feature of the mediating capacities of tools and is the basis for the non-neutrality of tool use (Ihde 1979, pp. 73–77).

Ihde's relatively older post-phenomenological approach does not involve any such explicit claim that the tools we make and engage with can be seen as extensions of our cognitive abilities. Ihde (1979, 1990) characterizes non-neutral tools primarily as extensions of our bodily or physiological capacities. However, if we adopt Menary's (2009) continuity thesis that there is no intrinsic difference between human cognitive capacities and human biological or physical capacities, then these flaked-stone tools can be seen as extensions of those ancient knappers' cognitive capacities as well. An extension of Ihde's views seem quite plausible in light of Menary's (2009, p. 31) key thesis that human (or hominin) cognitive capacities include, among others, manipulating the environment. What Ihde's post-phenomenological theory does not permit us

is to interpret tools or artifacts either as mere passive, neutral aids, or as genuine components of human (or hominin) cognitive processes. Being neither neutral intermediaries nor actual parts or constituents of hominin cognitive processes these prehistoric flaked-stone tools, as Ihde (1979, 1990) would suggest, had actively mediated the knapper-environment interactions and transformed hominin behavior (physical and cognitive) in quite unforeseen, unpredictable ways.

The closest possible convergence of Ihde's views with those of Malafouris' can be found in Ihde's (2008) critique of the individualistic notion of technological design. Examining several cases from the history of technology, Ihde (2008, p. 51) argues that the design-process operates in ways which involve a very complex and dynamic set of inter-relations between the designer or maker, the materials used for manufacturing, and the uses to which any such tool or artifact may be put. There are two interstices in this three-part relation, namely the designer-materiality interstice and the artifact-user interstice which attract notice. The former interstice precludes the common-sense notion of control over the inertness of the material as the interaction between the designer and the material is exploratory (Ihde 2008, p. 58). The material the designer is working with has the (mediating) capacity to hint at possible trajectories or to suggest further developments. Similarly in the artifact-user interstice, the indeterminacy involved in the multiple uses of artifacts indicates less control of the designer or maker on the one hand and the primacy of the users on the other (Ihde 2008, p. 58). Ihde's account is truly penetrating as in addition to the non-neutrality of mediating technologies it points at their co-constitutive nature as well. Though from Ihde's post-phenomenological perspective, tools or artifacts are co-constitutive of the results obtained by means of them and not of the cognitive processes involved in their production. Malafouris' description of a hybrid nature of human (or hominin) cognition entailing active interactions between varieties of extra-neural (bodily or artifactual) resources could provide a useful pointer for Ihde here. Ihde could have challenged the wide-spread individualistic notion of the (technological) design-process more forcefully using Malafouris' key insight that human cognitive processing is a hylonoetic field (Malafouris 2015, p. 366).

Extending Ihde's dynamic and interactive account of technological design to the prehistoric stone tool making process, Oldowan stone flaking can be seen as consisting of a set of intricate and dynamic inter-relations between the prehistoric knapper, i.e., the embodied agent, the volcanic rocks (such as lavas or ignimbrites or basement quartzes) commonly used as raw materials for Oldowan tools and the (possible) uses of those flaked-stone tools such as de-fleshing of the carcasses, or smashing of the bones. Ihde's (2008) tripartite human-technology-uses model with two pronounced interstices offers an immensely productive theoretical framework for understanding and explaining early hominin stone tool use and tool making activities. If one focuses on the designer-materiality interstice, one can understand how the volcanic rocks (the materials the prehistoric knappers worked with) had possibly suggested further flaking angles. On the other hand, if one looks into the artifact-user interstice, one can see the possibilities of multiple uses of early flaked-stone tools. Nevertheless, Ihde's post-phenomenological analysis of embodiment relations, particularly his interpretation of the "agent-tool" interface could be further refined with the help of Malafouris' (2013) observation that tools are not simply conjoined with pre-existing agents rather an

organism becomes an embodied agent only by actively engaging with the exosomatic tools (or artifacts).

Our present attempt at reviewing and integrating the theories of Ihde and Malafouris will hopefully provide new, productive directions for future philosophical-archaeological research and add to our understanding of how tools that we make and use shape us.

References

Adams, F., & Aizawa, K. (2009). Why the mind is still in the head. In P. Robbins & M. Aydede (Eds.), *The Cambridge handbook of situated cognition*. Cambridge: Cambridge University Press.

Beck, B. B. (1980). *Animal tool behavior: the use and manufacture of tools by animals*. New York: Garland STPM.

Bruner, E., & Iriki, A. (2016). Extending mind, visuospatial integration, and the evolution of the parietal lobes in the human genus. *Quaternary International, 405*, 98–110.

Bryne, R. W. (2004). The manual skills and cognition that lie behind hominid tool use. In A. E. Russon & D. R. Begun (Eds.), *The evolution of thought: Evolutionary origins of great ape intelligence* (pp. 31–44). Cambridge: Cambridge University Press.

Coolidge, F. L., & Wynn, T. (2016). An introduction to cognitive archaeology. *Current Directions in Psychological Science, 25*(6), 386–392.

Coolidge, F. L., & Wynn, T. (2017). *The rise of Homo sapiens: The evolution of modern thinking* (2nd ed.). Oxford: Oxford University Press.

Clark, G. (1977). *World prehistory in new perspective*. Cambridge: Cambridge University Press.

Clark, A. (2007). Re-inventing ourselves: the plasticity of embodiment, sensing, and mind. *The Journal of Medicine and Philosophy, 32*, 263–282.

Clark, A. (2008). *Supersizing the mind: Embodiment, action, and cognitive extension*. New York: Oxford University Press.

Delagnes, A., & Roche, H. (2005). Late Pliocene hominid knapping skills: the case of Lokalalei 2C, West Turkana, Kenya. *Journal of Human Evolution, 48*(5), 435−472.

De la Torre, I. (2011). The origins of stone tool technology in Africa: a historical perspective. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 366*(1567), 1028–1037.

De Beaune, S. A. (2004). The invention of technology: prehistory and cognition. *Current Anthropology, 45*(2), 139−162.

Donald, M. (2010). The exographic revolution: Neuropsychological sequelae. In L. Malafouris & C. Renfrew (Eds.), *The cognitive life of things: Recasting the boundaries of the mind* (pp. 71–79). Cambridge: McDonald Institute Monographs.

Gibson, J. J. (1977). The theory of affordances. In Perceiving, acting, and knowing: Toward an ecological psychology (pp. 127–143). Hillsdale, NJ: Lawrence Erlbaum.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge: MIT Press.

Hutchins, E. (2001). Cognitive artifact. In R. A. Wilson & F. C. Keil (Eds.), *The MIT encyclopedia of the cognitive sciences* (pp. 126–128). Cambridge: MIT Press.

Hutchins, E. (2008). The role of cultural practices in the emergence of modern human intelligence. *Philosophical Transactions of the Royal Society, 363*, 2011–2019.

Ihde, D. (1979). *Technics and praxis*. Dordrecht: D. Reidel Publishing Company.

Ihde, D. (1990). *Technology and the lifeworld. from garden to earth*. Bloomington: Indiana University Press.

Ihde, D. (2003). *Postphenomenology—again?* Aarhus: The Centre for STS Studies.

Ihde, D. (2007). Technologies—musics—embodiments. *Janus Head, 10*(1), 7–24.

Ihde, D. (2008). The designer fallacy and technological imagination. In P. E. Vermaas, P. Kroes, A. Light, S. A. Moore (Eds.), *Philosophy and design: From engineering to architecture*, Springer Science + Business Media B. V.

Ihde, D. (2009). *Postphenomenology and technoscience*. Albany: State University of New York Press.

Ihde, D. (2012). *Experimental phenomenology: Multistabilities* (2nd ed.). Albany: State University of New York Press.

Jeffares, B. (2010a). The co-evolution of tools and minds: cognition and material culture in the hominin lineage. *Phenomenology and the Cognitive Sciences, 9*, 503–520.

Jeffares, B. (2010b). The evolution of technical competence: strategic and economic thinking. In W. Christensen, E. Schier, & J. Sutton (Eds.), *ASCS09: Proceedings of the 9th conference of the Australasian Society for Cognitive Science* (pp. 162–169). Sydney: Macquarie Centre for Cognitive Science. https://doi.org/10.5096/ASCS200925.

Keller, C., & Keller, J. (1996). *Cognition and tool use: The blacksmith at work*. Cambridge: Cambridge University Press.

Leaky, M. (1971). *Olduvai Gorge: Volume 5: Excavations in beds I and II*. Cambridge: Cambridge University Press.

Lewis, J. E., & Harmand, S. (2016). An earlier origin for stone tool making: implications for cognitive evolution and the transition to *Homo*. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1698), 20150233.

Malafouris, L. (2008a). At the potter's wheel: An argument for material agency. In C. Knappett & L. Malafouris (Eds.), *Material agency: Towards a non-anthropocentric approach* (pp. 19–36). Berlin: Springer.

Malafouris, L. (2008b). Between brains, bodies and things: tectonoetic awareness and the extended self. *Philosophical Transaction of the Royal Society of London B, 363*, 1993–2002.

Malafouris, L. (2008c). Beads for a plastic mind: the "blind man's stick" (BMS) hypothesis and the active nature of material culture. *Cambridge Archaeological Journal, 18*(3), 401–414.

Malafouris, L. (2013). *How things shape the mind*. Cambridge: MIT Press.

Malafouris, L. (2015). Metaplasticity and the primacy of material engagement. *Time and Mind, 8*(4), 351–371.

Malafouris, L. (2016). Material engagement and the embodied mind. In T. Wynn & F. L. Coolidge (Eds.), *Cognitive models in Palaeolithic archaeology* (pp. 69–87). Oxford: Oxford University Press.

Malafouris, L., & Renfrew, C. (Eds.). (2010). *The cognitive life of things: Recasting the boundaries of the mind*. Cambridge: McDonald Institute.

Marzke, M. W. (1996). Evolution of the hand and bipedality. In A. Lock & C. R. Peters (Eds.), *Handbook of human symbolic evolution* (pp. 126–154). Oxford: Clarendon.

Marzke, M. W. (1997). Precision grips, hand morphology, and tools. *American Journal of Physical Anthropology, 102*(1), 91–110.

Menary, R. (2007). *Cognitive integration: mind and cognition unbounded*. Basingstoke: Palgrave Macmillan.

Menary, R. (2009). Intentionality, cognitive integration and the continuity thesis. *Topoi, 28*, 31–43.

Mithen, S. J. (1998 [1996]) The prehistory of the mind: a search for the origins of art, religion and science. London: Thames and Hudson.

Mithen, S., & Parsons, L. (2008). The brain as a cultural artefact. *Cambridge Archaeological Journal, 18*, 415–422.

Moore, M. W., & Perston, Y. (2016). Experimental insights into the cognitive significance of early stone tools. *PLoS One, 11*(7), e0158803. https://doi.org/10.1371/journal.pone.0158803.

Nowell, A., & Davidson, I. (Eds.). (2010). *Stone tools and the evolution of human cognition*. Boulder: University Press of Colorado.

Orban, G. A., & Caruana, F. (2014). The neural basis of human tool use. *Frontiers in Psychology, 5*, 1–12.

Ottoni, E. B. (2015). Tool use traditions in nonhuman primates: the case of tufted capuchin monkeys. *Human Ethology Bulletin* – Proc. of the XXII. ISHE Conference, 22–40.

Preston, B. (1998). Cognition and tool use. *Mind & Language, 13*(4), 513–547.

Proffitt, T., et al. (2016). Wild monkeys flake stone tools. *Nature, 539*(7627), 85–88.

Schick, K. D., & Toth, N. P. (1993). *Making silent stones speak: Human evolution and the dawn of technology*. London: Weidenfeld and Nicholson.

Sterelny, K. (2010). Minds: extended or scaffolded? *Phenomenology and the Cognitive Sciences*. https://doi.org/10.1007/s11097-010-9174-y.

Stout, D. (2002). Skill and cognition in stone tool production: an ethnographic case study from Irian Jaya. *Current Anthropology, 43*(5), 693–722.

Stout, D. (2008). Technology and human brain evolution. *General Anthropology, 15*(2), 1–5.

Stout, D. (2011). Stone tool making and the evolution of human culture and cognition. *Philosophical Transactions of the Royal Society of London Series B, 366*, 1050–1059.

Stout, D., & Chaminade, T. (2007). The evolutionary neuroscience of tool making. *Neuropsychologia, 45*, 1091–1100.

Stout, D. and Chaminade, T. (2009). Making tools and making sense: complex, intentional behaviour in human evolution. Cambridge Archaeological Journal 19(1): 85–96.

Stout, D., Toth, N., Schick, K., & Chaminade, T. (2008). Neural correlates of early stone age tool making: technology, language and cognition in human evolution. *Philosophical Transactions of the Royal Society of London series B, 363*, 1939–1949.

Stotz, K. (2010). Human nature and cognitive-developmental niche construction. *Phenomenology and the Cognitive Sciences*. https://doi.org/10.1007/s11097-010-9178-7.

Toth, N. (1985). The Oldowan reassessed: a close look at early stone artifacts. *Journal of Archaeological Science, 12*, 101–120.

Toth, N. (1987). The first technology. *Scientific American, 1*, 112–121.

Toth, N., & Schick, K. D. (2009). The Oldowan: the tool making of early hominins and chimpanzees compared. *Annual Review of Anthropology, 38*, 289–305.

Toth, N., et al. (1993). Pan the tool-maker: investigations into the stone tool-making and tool using capabilities of a bonobo. *Journal of Archaeological Science, 20*, 81–91.

Toth, N., Schick, K. D., & Semaw, S. (2006). A comparative study of the stone-tool making skills of Pan, Australopithecus, and Homo sapiens. In N. Toth & K. Schick (Eds.), *The Oldowan: Case studies into the earliest stone age*. Gosport: Stone Age Institute Press.

Washburn, S. L. (1978). The evolution of man. *Scientific American*, 194–209.

Woelert, P. (2014). Tool use and the human mind: from basic to materially mediated operational intentionality. *Cognitive Semiotics*. https://doi.org/10.1515/cogsem-2014-0014.

Wynn, T. (1993). Layers of thinking in tool behaviour. In K. R. Gibson & T. Ingold (Eds.), *Tools, language and cognition in human evolution* (pp. 389–406). Cambridge: Cambridge University Press.

Wynn, T. (2002). Archaeology and cognitive evolution. *Behavioural and Brain Sciences, 25*(3), 389–438.

Wynn, T. (2009). Hafted spears and the archaeology of mind. *Proceedings of the National Academy of Sciences, 106*(24), 9544–9545.

Wynn, T., & Coolidge, F. L. (2016). Archaeological insights into hominin cognitive evolution. *Evolutionary Anthropology: Issues, News, and Reviews, 25*(4), 200–213.

Wynn, T. G., & Coolidge, F. L. (Eds.). (2017). Cognitive models in Palaeolithic archaeology. Oxford University Press.

Wynn, T. G., & McGrew, W. C. (1989). An Ape's view of the Oldowan. *Man, New Series, 24*(3), 383–398.

Wynn, T., Hernandez-Aguilar, R. A., Marchant, L. F., & McGrew, W. C. (2011). An ape's view of the Oldowan revisited. *Evolutionary Anthropology, 20*(5), 181–197.