Neanderthal cognitive equivalence: epistemological problems and a critical analysis from radical embodiment

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Summary

The emergence of early body ornaments in the archaeological record of late Neanderthal populations in Europe has been considered to be proof of cognitive equivalence between Neanderthals and modern humans. However, these conclusions are reached through the adoption of a non-analytic method. A notion of behavioral modernity is indeed used to classify some behaviors in the archaeological record and intuitively connect these practices to cognitive modernity. The current thesis raises epistemological and metaphysical arguments against the use of behavioral modernity in cognitive archaeology, arguing for abandoning this notion in this field. A new methodology for the rational validation of theories, named holistic mapping, it is proposed to overcome problems with the current methodological approaches. Grounded in a combination of conditional/processual cognitive archaeology and the post-processual interpretive approach, holistic mapping focuses on the idea that inferences between the archaeological record and the cognitive level must result from an analytic process constituted by two stages. First, behavioral practices reconstructed from the record are mapped onto the minimal cognitive conditions required to produce them. Second, theoretical alternatives thus generated are selected by evaluating their stability within a network of theories concerning the entire behavioral repertoire of a target hominin species. These conditional principles are applied here to the production of shell-bead body ornaments. Conceptual tools from radical embodied cognitive science are adopted to show that these body ornaments do not necessarily require presumable signature properties of modern cognition. Indeed, direct social perception informed by context-related memories shows capable of explaining these ornaments without tapping into high-level mindreading or abstract conceptualization. Furthermore, preliminary analyses based on Barnard´s (2010a) Interacting cognitive subsystems model show that the radical embodied abilities reported here are compatible with a primitive mental architecture.

Material engagement theory (Malafouris, 2013) is used to argue that the emergence of fully symbolic ornaments and meta-representational abilities necessarily require the engagement with non-symbolic material scaffolds to be brought forth. The absence of clear evidence for such a scaffolding in Neanderthal material culture impedes to consider early body ornaments as symbols and in turn as proof of high-level mentalistic abilities.

It is concluded that early body ornaments are currently unable to rule out the existence of cognitive differences between Neanderthals and modern humans.

Zusammenfassung

Das frühe Auftreten von Körperschmuck in den archäologischen Hinterlassenschaften später Neandertaler-Populationen in Europa wurde als Beleg kognitiver Äquivalenz zwischen Neandertalern und modernen Menschen gewertet. Diese Annahme gründet jedoch auf der Verwendung nicht-analytischer Methoden. Vielmehr wird ein Begriff modernen Verhaltens benutzt um bestimmte Verhaltensweisen im archäologischen Befund zu klassifizieren und diese dann mit kognitiver Modernität zu verknüpfen. Die vorliegende Dissertation führt epistemologische und philosophisch-metaphysische Argumente gegen die Verwendung des Begriffs von modernem Verhalten in der kognitiven Archäologie an und spricht sich für die Aufgabe des Begriffes in diesem Bereich aus. In diesem Zusammenhang wird eine neue Methodik zur rationalen Bewertung von Theorien vorgeschlagen, das *holistic mapping* oder die ganzheitliche Zuordnung, um die Probleme bestehender erkenntnistheoretischer Ansätze zu überwinden. Beruhend auf einer Kombination aus bedingter bzw. prozessualer kognitiver Archäologie und dem postprozessualen, interpretativen Ansatz, setzt holistic mapping einen Schwerpunkt auf das Konzept, dass Rückschlüsse vom archäologischen Befund auf die kognitive Ebene in einem in zwei Stufen gegliederten analytischen Prozess gezogen werden müssen. Erstens müssen Verhaltensweisen, die vom Befund ausgehend rekonstruiert wurden, dem für ihre Ausführung notwendigen Mindestmaß kognitiver Bedingungen zugeordnet werden. In einem zweiten Schritt wird dann aus den so erzeugten theoretischen Alternativen eine Auswahl getroffen, indem ihre Konsistenz innerhalb des Netzwerks der Theorien bezüglich des gesamten Verhaltensrepertoires der zu untersuchenden Homininen bewertet wird.

Diese bedingenden Prinzipien werden hier auf die Herstellung von Muschelperlen als Körperschmuck angewendet. Um zu zeigen, dass derartiger Körperschmuck nicht, wie häufig angenommen, notwendigerweise charakteristische Eigenschaften moderner Kognition voraussetzt, werden konzeptionelle Werkzeuge des kognitionswissenschaftlichen Ansatzes des *radical embodiment* bzw. der durchgreifenden Verkörperung eingesetzt. Tatsächlich erweist sich direkte soziale Wahrnehmung geprägt durch kontext-bezogene Erinnerung als dazu geeignet, das Vorhandensein solcher Ornamente zu erklären, ohne von hochentwickelten Fähigkeiten zum Verständnis der Gedanken anderer oder abstrakter Konzeptualisierung ausgehen zu müssen. Darüber hinaus zeigen vorläufige Analysen, die auf Barnards (2010a) „Interacting Cognitive

Subsystems Model“ basieren, dass die hier beschriebenen radikal verkörperten Fähigkeiten vereinbar sind mit einer primitiven mentalen Architektur.

Des Weiteren wird die „*Material Engagement Theory*“ (Malafouris, 2013) angewandt um zu darzulegen, dass die Entwicklung vollständig symbolischer Ornamentik und der Fähigkeit zu geistiger Meta-Repräsentation notwendigerweise den Umgang mit einem nicht-symbolischen, materiellen Gerüst erfordert. Die Abwesenheit klarer Hinweise auf ein solches Gerüst in der materiellen Kultur des Neandertalers erschwert die Ansprache frühen Körperschmucks als Symbole und dementsprechend als Hinweis auf hochentwickelte geistige Fähigkeiten.

Es wird der Schluss gezogen, dass früher Körperschmuck beim momentanen Forschungsstand nicht dazu geeignet ist, das Vorhandensein kognitiver Unterschiede zwischen Neandertalern und modernen Menschen auszuschließen.

List of publications in the thesis

A. Accepted works

Garofoli, D. & Haidle, M.N. (2014). Epistemological problems in cognitive archaeology: an anti-relativistic agenda towards methodological uniformity. *Journal of Anthropological Sciences*, *92*, 7-41.

Garofoli, D. (2013a). Comment on "Trees and ladders: A critique of the theory of human cognitive and behavioural evolution in Palaeolithic archaeology" by Langbroek, M. (Quaternary International 270: 4-14). *Quaternary International*, *299*, 116-118.

Garofoli D. Cognitive archaeology without behavioral modernity: An eliminativist attempt (forthcoming a). In Iliopoulos, A. & Garofoli, D. (Eds.), "*The material dimensions of cognition*", *Quaternary International* special issue. doi:10.1016/j.quaint.2015.06.061

Garofoli, D. (forthcoming b). Do early body ornaments prove cognitive modernity? A critical analysis from situated cognition. *Phenomenology and the Cognitive Sciences*. doi: 10.1007/s11097-014-9356-0.

Garofoli, D. (2013b). Critique of *How things shape the mind. A theory of Material Engagement*, by Lambros Malafouris. *Journal of Mind and Behavior, 34*(3-4), 299-310.

Personal contribution

The current thesis is the product of an individual research project lasting approximately four years. I am indeed the only author for almost all the papers that are part of this cumulative endeavor. The methodologies and applied theories I have developed here therefore stand as my personal contribution to the field of cognitive archaeology. Dr. Miriam Haidle has co-authored with me an important paper (i.e., Garofoli & Haidle, 2014, appendix A.1), which explains the basic tenets of my epistemological approach. Cognitive archaeology is a massive multidisciplinary field that implies communication of complex notions between different scientific communities. Given her experience as a cognitive archaeology pioneer, Dr. Haidle has contributed to make this paper more accessible to the non-specialists. In this way, she has provided support in the ideation of visual schemas and pictures that could represent material anchors for better clarifying some core aspects of the argument. Likewise, she has assisted with the reduction of the epistemological jargon in several sections of the paper. However, the conceptual ideas at the basis of this methodology stand as my own. The current PhD thesis has not been developed for commercial reasons.

1. Introduction

Cognitive archaeology is a raising discipline that attempts to reconstruct the properties of ancient minds by studying the behavioral traces left by extinct human populations in the archaeological record. During the last thirty years, the initial skepticism towards the possibility of a "paleopsychology" (Binford, 1965) was overcome by the joint efforts of scholars delving into different domains of knowledge. Cognitive archaeology is currently defined by a combination of approaches in empirical archaeology (e.g., R.G. Klein, 2008; Haidle, 2010; McBrearty & Brooks, 2000; Wadley, 2013; Zilhão, 2011a), paleoanthropology (e.g., Benazzi et al., 2011; D´Anastasio et al., 2013), archaeological theory (Hodder, 2012; Knappett, 2005; Renfrew, 1994), epistemology (Bell, 1994; Dubreuil, 2011), paleodemography (Ambrose, 1998; Shennan, 2001), paleoneurology (Bruner, 2010), cognitive neuroscience (Coolidge & Wynn, 2005; Stout & Chaminade, 2007), embodied cognition (Malafouris, 2013), evolutionary psychology (Mithen, 1996), semiotics (Preucel, 2007), linguistics (Botha, 2010; Boeckx, 2013; Noble & Davidson, 1996), genetics (Krause et al., 2007) and philosophy (Sterelny, 2003). Nevertheless, the production of a coherent multidisciplinary domain requires going beyond the mere juxtaposition of multiple fields by integrating different sources of knowledge within a unitary perspective.

The current thesis attempts to apply such an integrated massive multidisciplinary approach to one of the most controversial topics in cognitive archaeology. It focuses on the problem of Neanderthal cognition and its relationship with modern human cognitive potential. Such a theme represents the modern derivate of a deeply rooted debate concerning the problem of "Neanderthal humanity" (Cochran & Harpending, 2009). Since their emergence within the palaeoanthropological record, Neanderthal remains did not fit with the expectations of scholars educated in a Western-country industrial context. The central dogma that modern humans were the complete, adaptively successful human model (Malafouris, 2013) was confronted by the emergence of a large-brained hominin that looked quite similar to living humans. After a failed attempt to consider Neanderthals as feral humans (see Zilhão, 2012), the initial intuitions were maintained by arguing for the intellectual superiority of modern humans over Neanderthals. This required empirically proving that modern human material culture was disproportionately more complex than the simpler Neanderthal one.

However, the emergence of critical theory and its post-processual echoes in archaeological theory (e.g., Hodder and Hutson, 2003, chapter 9) created the bases for a reflective reconsideration of the mentality of Western-world archaeologists. Thus, some scholars acknowledged the existence of modern-centric biases in judging Neanderthals against the standard of modern perfection (e.g., Zilhão, 2014, p. 52). A new agenda stemmed from these reflections and purposed to demonstrate that Neanderthals were not cognitively inferior to modern humans. In consequence, a gradual opposition arose between supporters of two academic "factions". On the one hand some scholars, in line with the tradition, ascribed to Neanderthals less sophisticated planning abilities, limited language faculties and a less complex social organization than modern humans (Ambrose, 2010; Binford, 1989; Bruner, 2004; R.G. Klein, 2009; Lewis-Williams, 2002; Lieberman, 1989; Mellars, 1996; Mithen, 1996; Soffer, 1994; Stringer & Gamble, 1993; Wynn & Coolidge, 2004). On the other hand, partisans of the equivalence model argued for the existence of marginal differences between Neanderthal and modern human behavior, which are limited to the presence of artistic manifestations (e.g., parietal art or ivory figurines) in the modern human Upper Paleolithic record. These scholars considered these unique modern-human innovations as the product of cultural development, rather than as a proof of biological differences between the two species (Churchill, 2014; Clark & Lindly, 1989; d´Errico, 2003; Hayden, 1993; Simek, 1992; Speth, 2004; Villa & Roebroeks, 2014; Zilhão, 2007).

During the last years, the debate about cognitive equivalence has assumed traits that clearly depart from the very scientific domain. Among them, it is worth noting the use of political terminology (Speth, 2004), reference to religion (Balter, 2012), allegations of racism and harsh replies (Cochran & Harpending, 2009). This strengthens the suspect that some deep intuitions, pertaining to the social sphere (Haidt, 2001), might have assumed great relevance within this diatribe (Zilhão, 2014, p. 52). Intuitions are processes of direct knowledge acquisition that omit an inferential connection between premises and conclusions (G. Klein, 1998). In contrast, intuitions represent fast and unconscious judgments grounded in emotionally laden contexts in which scholars are situated (Isenberg, 1984; Volz & von Cramon, 2006). In this way, a context based on deep egalitarian convictions and emotionally charged with a feeling of guilt for having been diminishing Neanderthals for decades (Papagianni & Morse, 2013) could have grounded intuitions about Neanderthal cognitive equivalence. This might lead to a radicalization of the equivalence agenda, which risks to generate new dogmatic positions as opposed to the old modern-centric ones. As human history teaches us, revolutionary events often lead to the replacement of a tyrant with another one. Thus, a welcome criticism of the old-fashioned modernity bias (e.g., Latour, 1991) and superiority complex (Villa & Roebroeks, 2014) ought not to lead to a likewise problematic "tyranny of equality".

The current thesis advocates a reappraisal of the conditional approach in cognitive archaeology (Abramyuk, 2012, p. 30-33; Bell, 1994; Renfrew, 1994). It aims to revitalize and at the same time reform a cognitive archaeology that is firmly grounded on the analysis of the archaeological record. Conclusions about human cognitive equivalence ought to be uniquely derived from the analysis of behaviors reconstructed from the record and their mapping onto the necessary cognitive conditions to realize them. This analytic focus requires abandoning aprioristic convictions and limiting the role of intuitions in theory production (Langbroek, 2012). There is no doubt that reaching this meta-perspective, namely a Machian view of ourselves looking at "ourselves looking at the world" (Fig. 1), is a difficult enterprise. Not by chance, previous recommendations for the acquisition of a similar objectivity in cognitive archaeology (Mellars, 1996) faded in the background.

However, the very definition of anthropology (and cognitive archaeology as a constituent branch) as the study of human beings by human beings makes this challenge both indispensable and unavoidable.

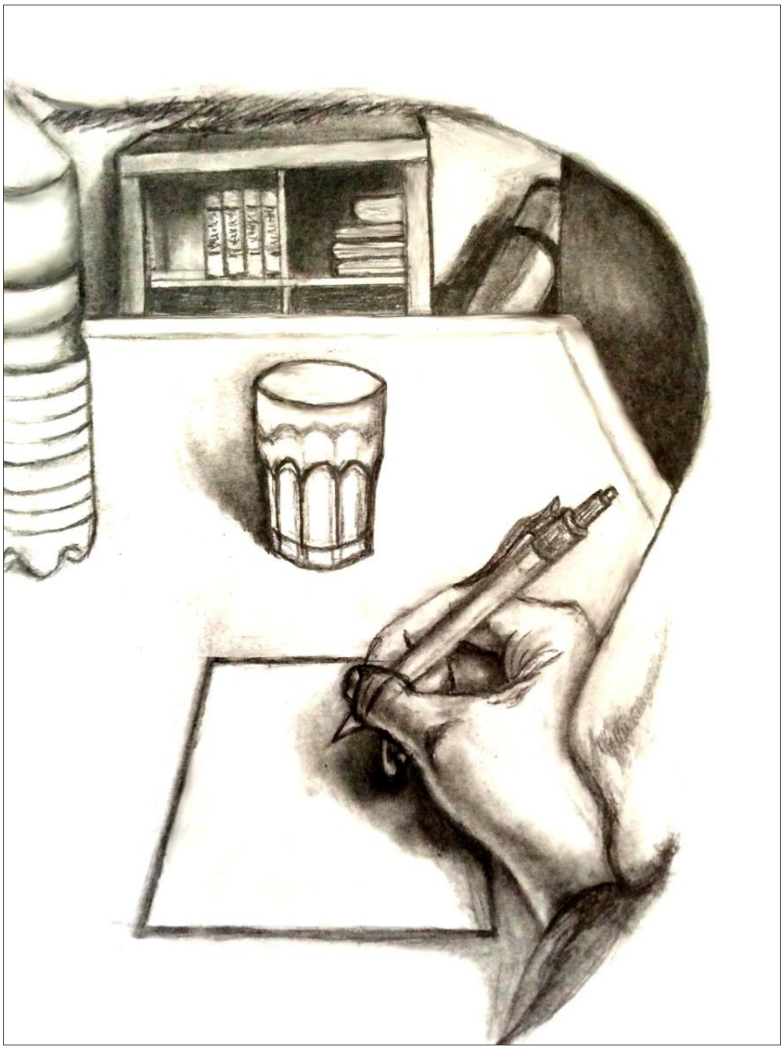

Figure 1: A Machian view. The viewer acquires a meta-perspective, through which he can look at himself looking at the world. This image represents a condition that needs to be reached in cognitive archaeology, in order to have an intuition-free approach to the archaeological record. Redrawn by Duilio Garofoli after Mach (1914, p. 19).

2. Behavioral modernity and cognitive equivalence

The cognitive equivalence debate is apparently grounded into an implicit premise, which resonates with Franz Boas´ principle of uniformity among living people (Boas, 1940; see Conard, 2010). This tenet implies that all modern humans are characterized by a specific set of behaviors, which in turn entail the existence of shared underlying psychological mechanisms. Within these terms, a search for cognitive equivalence in the archaeological record entails identifying artifacts and behavioral practices that fall within a category of "behavioral modernity" (henceforth BM). From this level, it is considered possible to draw inferences about the equivalence of the cognitive properties of populations associated with such modern traits. Great efforts have been therefore focused on defining a concept of BM that could allow reaching this research aim.

A first general approach to identify BM is based upon constructing lists of behaviorally modern traits (Nowell, 2010), purposing to identify a "gold standard" for modernity. Human species/populations are judged to have reached a condition of BM if their material culture meets such a standard. Although broadly adopted during the past, this list-based approach has gradually proven incoherent. From a descriptive level, ethnographic literature showed that also some historical modern human populations do not fit with the proposed descriptive lists (Deacon, 1990; d´Errico, 2003). These populations show indeed an extensive variability with the categories of behaviors listed in the BM standard. This leads to the paradox that even some contemporary modern human populations are not behaviorally modern. From a normative level, it is unclear why some specific components of the typical modern human behavioral repertoire ought to be considered as modern, whereas others were to be classified as archaic. For example, the normative conditions to consider apparently complex and laborious Levallois reductions (Boëda, 1995) as archaic, whereas the production of laminar technologies as modern (d´Errico, 2003, p. 192 and references therein) were never clearly spelled out. Nor was the introduction of more cognitively oriented categories for defining BM, like planning depth, behavioral innovativeness, abstract thinking, social complexity, etc. (McBrearty & Brooks, 2000) considered as sufficient to escape from a sense of relativism that permeated the list-based approach (Chase, 2003; Belfer-Cohen & Hovers, 2010; Soffer, 2009; Wadley, 2001).

As a reaction to these problems, a second general approach to BM emerged, which focuses on defining the essence of what it means to be human. According to Nowell (2010), the vast majority of archaeologists nowadays agree that what "distinguishes moderns from the ancients" (Stringer & Gamble, 1993 p. 207) lies in symbolically mediated behaviors (Barham, 2013; Chase, 2003, p. 637, 2006; Davidson & Noble, 1989; Henshilwood, 2007; Henshilwood & Marean, 2003; Noble & Davidson, 1991; Marean, 2007; Soffer, 2009; Stringer & Gamble, 1993; Texier et al., 2010; Wadley, 2001). Drawing from Wadley (2001), Henshilwood & Marean (2003) coined the expression "fully symbolic *sapiens* behavior" to indicate the construction of symbolically mediated social lives, which extend from the production of linguistically mediated behaviors to the storage of symbolic information in material culture.

In the next sections, these criteria for defining BM will be used to illustrate the core tenets of the most relevant models currently adopted in human cognitive evolution. The traditional "revolutionary" proposal will be contrasted with its cognitive equivalence rivals. Furthermore, moderate versions of the cognitive equivalence agenda, which ascribe BM to the sole modern human species, but assumes an equivalence between all modern human populations, will be compared with a more extreme approach. This latter one, according to which also Neanderthals were the cognitive equal of modern humans, represents the target of the analysis proposed in this thesis.

2.1 - The "human revolution" model

Upper Palaeolithic material culture is characterized by the presence of artifacts like body ornaments, musical instruments, ivory figurines, prismatic cores and blades, complex weapons, which have been considered as emblematic instances of BM (Bar-Yosef, 1998; R.G. Klein, 2009; R.G. Klein & Edgar, 2002; Mellars, 2005). This archaeological evidence, coupled with the exclusive presence of modern human skeletal remains in the European Upper Palaeolithic, led to the conviction that modern behavior and anatomy emerged as a single evolutionary package at ca 40 kya in Europe. For long time the dominant paradigm depicted therefore a human revolution scenario.

However, during the last decade, several lines of evidence have reduced the validity of the revolutionary model. A larger accessibility to the African record has led to uncover skeletal remains of modern human populations dating back to ca 200 kya in the Middle Stone Age (McDougal et al., 2005; White et al., 2003). By these new lights, the idea of a technological revolution caused by the rise of a modern phenotype was weakened. Advocates of the human revolution model justify this disconnection between modern anatomy and behavior by claiming that early modern human populations were not neurologically and cognitively modern. They assume that the Upper Palaeolithic technological revolution was the product of a mutational enhancement in the neurobiology of some early modern human populations´ brain in South Africa around ca 60 kya (R.G. Klein, 2003, 2008; Mellars, 2006). This was coupled with the limited emergence of Upper Paleolithic-like artifacts in Africa, which were considered as the roots of the European Upper Paleolithic (Mellars, 2006). Equipped with an augmented neuro-cognitive architecture, these fully modern humans reached Europe and gave rise to the full explosion of innovation that characterizes the Upper Palaeolithic.

2.2 - Early modern human cognitive equivalence

Some moderate supporters of the cognitive equivalence agenda disagree with the core tenets of the revolutionary model. They attempt to demonstrate that early modern human populations were the cognitive equivalent of contemporary ones by considering two different levels of analysis. At the empirical level, these scholars argue that the archaeological record shows an earlier emergence of BM in human prehistory than the threshold of 60 kya theorized by R.G. Klein (2008, 2009).

During the last decade, artifacts that were previously considered as typical of the European Upper Palaeolithic were found in significant association with several Middle Stone Age African sites, starting from ca 100 kya (Conard 2008). The most striking findings regarded several pieces of engraved ochre (see Anderson, 2012, for review), which were found at the South African sites of Blombos ca 77 kya (d´Errico et al., 2001; Henshilwood et al., 2002), 75-100 kya (Henshilwood et al., 2009) and Klein Kliphuis (88 kya, Mackay & Welz, 2008). Additional evidence was provided by engraved ostrich eggshells at Diepkloof, dated at 55-75 kya (Parkington et al., 2005; Texier et al., 2010). Pierced shell beads appeared in several MSA sites, often in combination with engraved objects. They were found at Blombos Cave in South Africa at ca 78 kya (d'Errico et al., 2005), at the Taforalt, Ifri n'Ammar and Rhafas sites in Marocco at ca 85-70 kya (Bouzouggar et al., 2007; d´Errico et al., 2009), at Oued Djebbana in Algeria at presumably ca 100 kya (Vanhaeren et al., 2006) and at Qafzeh and Skhul in Israel at 100-135 kya (Bar-Yosef et al., 2009; Vanhaeren et al., 2006). These artifacts overall were considered to be expression of symbolic behavior and thus proof of BM according to the essential category postulated by Henshilwood & Marean (2003). In addition to this essence-based definition of BM, the Middle Stone Age archaeological record shows also an accumulation of other modern behavioral traits that fit with a list-based conception of BM (d´Errico & Stringer, 2011; McBrearty & Brooks, 2000). In particular, foliate bifacial points make their appearance in the Still Bay industry at ca 70 kya (Henshilwood, 2009). Small retouched blades characterize the Howiesons Poort assemblages between 65 and 59 kya (ibidem). Similar blade technologies are reported at Twin Rivers and Kalambo Falls, Zambia, dated at approximately 300 kya (Barham, 2001) and presumably at Pinnacle Point, South Africa, at 160 kya (Marean et al., 2007).

The use of fire to improve the quality of tools has been attested at Pinnacle Point, Mossel Bay, at 72 kya and possibly as early as 164 kya (Brown et al., 2009). Similarly, hafting technologies that require the use of heat to produce compounded adhesives for the production of composite weapons is reported at Sibudu Cave in the Howiesons Poort layers (Wadley et al., 2009; Wadley, 2010). Bone tool technologies are reported at Katanda, Central Africa, where harpoons derived from mammal limbs are possibly dated back at ca 90 kya (Yellen et al., 1995). Instances of fully shaped bone tools like polished projectile points are found at southern African Still Bay and Howiesons Poort sites such as Blombos and Sibudu (Henshilwood et al., 2001; d´Errico & Henshilwood, 2007).

The gradual accumulation of these artifacts in the record is adopted to show that BM was incrementally acquired within a long time scale and did not emerge as a consequence of a discrete event (e.g., Knight et al., 1995; McBrearty & Brooks, 2000). The absence of a clear-cut threshold for BM in the archaeological record argues against one of the core tenets of the human revolution model. At a more theoretical level, evidence for gradualism is used to reject the idea that a discrete mutational enhancement in some early modern human populations at ca 60 kya was responsible for the acquisition of BM. A discrete mutational event shows lacunas in explaining the wide temporal and spatial distribution of these artifacts in the Middle Stone Age. Modern humans are considered more plausibly to emerge from a speciation event at ca 200 kya, equipped with a modern cognitive architecture (McBrearty & Brooks, 2000). Behaviorally modern technologies were developed as adaptive responses to new socio-demographic circumstances related to environmental and climatic variations (Ambrose, 1998; Kuhn & Stiner, 2006; Lahr & Foley, 1998).

In sum, this model assumes that BM emerged early in modern human prehistory as a result of a gradual process of cultural evolution. This process was undertaken by populations provided with human brains and minds. BM is hence considered as a prerogative of *Homo sapiens*.

2.3 - Neanderthal cognitive equivalence

A more extreme approach rejects the idea that BM is limited to modern humans. Proponents of the "multiregional model for BM" (Burdukiewicz, 2014; d´Errico, 2003, 2007; Speth, 2004; Villa & Roebroeks, 2014; Zilhão, 2007, 2011a, 2011b) argue that BM artifacts are present also in the material culture of archaic human species and in particular in the archaeological record of late Neanderthal populations in Europe. By applying the criteria for BM discussed earlier (McBrearty & Brooks, 2000) to Neanderthal material culture, no neat qualitative distinction was found with synchronous Middle Stone Age modern human populations in Africa. Updating d´Errico´s (2003) initial results with the most significant new data, the presence of BM in the Neanderthal record is currently supported by the following categories of artifacts/ behaviors:

a) *Organizational abilities*: The finding of six miraculously preserved wooden spears associated with horse bones at the German Lower Paleolithic site of Schöningen (Thieme, 2005) showed that *Homo heidelbergensis* populations were committed to big game hunting at ca 320 kya (Urban, Sierralta, and Frechen, 2011). Various archaeological sites dated within a time range from ca 200 kya (e.g., Biache-Saint-Vaast, Mauran, La Borde) and ca 56 kya (e.g., Salzgitter-Lebenstedt) show evidence of Neanderthal processing of large bovids, horses, reindeers and even bears (e.g., Gaudzinski & Roebroeks, 2000; Marean & Assefa, 1999). This proves that also Neanderthals were big game hunters and not scavengers (Villa et al., 2005). However, they were not obligated big game hunters and their game included also birds, showing potential variability (Hardy et al., 2013). Evidence of the use of marine resources, although limited, comes from Payre, Ardèche, France, ca 125–250 kya (Hardy & Moncel, 2011), and from the Late Mousterian level of Figuiera Brava, Portugal and Vanguard cave, Gibraltar, which is comparable with a typical Upper Paleolithic use (Fernandez-Jalvo & Andrews, 2000).

b) *Lithic technologies*: Chatelperronian sites in France and Spain show that Neanderthals were capable of producing blade technologies, although of a different kind from the Aurignacian ones (d´Errico et al., 1998). Furthermore, these artifacts show a level of tool standardization that is similar to that expressed in the Still Bay and Howiesons Poort techno-complexes.

c) *Hafting*: Traces of hafting technologies have been found in association with some Middle Palaeolithic sites in Europe and Eurasia. The Syrian site of Umm El Tlel (ca 60 kya), shows the presence of a scraper and some cortical flakes with traces of bitumen adhesive used for hafting (Boëda et al., 1998). At the same location, direct evidence of stone-tipped spears comes in a Levallois point embedded in the third cervical vertebra of a wild horse (Boëda et al., 1999). Evidence of birch bark pitch hafting (Mazza et al., 2006) is present at Campitello (Italy), dated by faunal association within the late Middle Pleistocene (ca 200 kya). Additional evidence of birch-bark pitch hafting has been found at the German Middle Paleolithic sites of Königsaue, ca 40-80 kya (Grünberg, 2002; Köller et al., 2001), and Inden-Altdorf, ca 120 kya (Pawlik & Thissen, 2011).

d) *Bone and Ivory working*: Evidence from French Chatelperronian sites shows that late Neanderthal populations made use of worked, if not decorated, ivory tools (d´Errico et al., 1998; d´Errico et al., 2003a; Soressi et al., 2013).

e) *Burials*: Neanderthals are considered to bury their people (but see Gargett, 1989; Goldberg et al., 2013) although the association with grave goods and the involvement of potential symbolic/ritual aspects are currently debated (Chase & Dibble, 1987; Mellars, 1996; Walker et al., 2012; Wynn & Coolidge, 2012, pp. 105-112). Evidence of Neanderthal burials are present for example at Tabun, at 112-143 kya (Grün & Stringer, 2000) and at the French site of La Ferrasie at ca 68 kya (Mellars, 1996, pp. 375-381). Importantly, such burials appear to be quite similar to the modern human Qafzeh ones (d´Errico et al., 2003b).

f) *Color*: Black pigments and ochre to a minor extent come from 70 layers excavated from 40 Neanderthal sites. The richest collection comes from the Mousterian of Acheulean tradition levels of Pech-de-l´Azé (ca 50-60 kya) and show evidence of scratches related to use (d´Errico & Soressi, 2002). At the Cioarei cave, Romania, ochre fragments were found in a Mousterian layer dated before 50 kya (Carciumaru et al., 2002), whereas some red ochre findings at Maastricht Belvedere locates evidence around a limit of 200-250 kya (Roebroeks et al., 2012).

g) *Personal ornaments*: Particular attention is focused on the emergence of symbolism, which is considered to be the signature property of an "essentially modern" behavior. Late Neanderthal sites in Europe show evidence of body adornment comparable with those produced by modern humans in the Middle Stone Age. Shell beads come from Grotte du Renne (d´Errico et al., 1998; Caron et al., 2011; Zilhão, 2012) at the Chatelperronian site of Arcy sur Cure (43-45 kya) and from Cueva de los Aviones (ca 50 kya) and Cueva Anton (ca 40 kya) in Spain (Zilhão et al., 2010). Hare and wolf bones unrelated to tool-use and presumably used as pendants come from Buran Kaya III in Crimea (d´Errico & Laroulandie, 2000). Besides the use of shell-beads, recent evidence supports the removal of feathers (Peresani et al., 2011; Finlayson et al., 2012) and claws (Morin & Laroulandie, 2012) from birds that are considered of scarce importance for nourishing. The unlikely adoption of these components in practical task suggests their use as body ornaments. The existence of fully symbolic abilities in Neanderthals is also indirectly supported by a series of additional behaviors that predate and coexist with early body adornment practices.

According to Zilhão (2007, 2011a), birch bark pitch hafting and burials prove the existence of abstractions and linguistic capabilities "as we know them".

Crucially, partisans of cognitive equivalence argue that Neanderthal populations showed evidence of fully sapiens symbolic behaviors prior to the income of modern humans in Europe (d´Errico, 2003; Zilhão, 2007, 2011b, 2012). BM artifacts in the archaeological record of Neanderthals are considered to predate the presence of modern humans in the European continent. According to Zilhão (2007), reliable evidence of modern human skeletal remains in Europe is attested at Peste cu Oase, Romania, not earlier than 35 kya (but see Higham et al., 2011, for a counterargument). This presents two different possibilities for the emergence of transitional industries in the European Middle Paleolithic. On the one hand, conceptual information could have been transferred deep into the Neanderthal world by a cultural chain that connected the first modern human colons in the Near East to Neanderthal populations in Western Europe. Since the directionality of this process is not necessarily oriented from modern humans to Neanderthals, it is reasonable that modern human incomers could have even learnt some innovative behaviors from indigenous Neanderthal populations. However, this proposal is exposed to the "impossible coincidence" objection (Mellars, 2005). According to this criticism, the chronology of the emergence of transitional industries is rather suspect, since late Neanderthal populations started to produce transitional artifacts in close proximity with the advent of modern humans. This suggests that Neanderthals were incapable of autonomously developing an Upper Paleolithic culture. The few instances of transitional industries ascribed to Neanderthals were produced instead by imitating modern human innovations without fully understanding them, a model best known as "acculturation". This position is consistent with the idea that Neanderthals had limited cognitive functions compared with modern humans. However, Zilhão (2007, 2011a) replies to this objection, claiming that the transfer of information along this cultural chain could not reach thus far without a full understanding of the meaning involved. This in turn entails the existence of equivalent cognitive abilities at both the sides of the chain.

On the other hand, the emergence of BM in transitional industries could reflect a process of independent development of innovative behaviors by Neanderthals. Such a proposal, championed by Zilhão (2007), bolsters the thesis of cognitive equivalence while being thoroughly immune to the impossible coincidence argument.

The two models discussed above raise powerful qualitative arguments in defense of a genuine acquisition of BM by Neanderthals. In consequence, a further attempt to defend the idea that BM is a prerogative of modern humans was performed at the quantitative level (Mellars, 1996; Wynn & Coolidge, 2004). The traces of BM artifacts in Neanderthal archaeological contexts were too limited when compared to the great abundance of the same categories of artifacts (and extremely more complex ones) in the modern human Upper Paleolithic record. However, d´Errico (2003) contends that the presence of the same behaviors in the modern human MSA is likewise scant. Furthermore, the Upper Paleolithic behavioral traits that have no counterpart in Neanderthal material culture (i.e., art, ivory figurines, etc.) do not represent the average character of *Homo sapiens* behavior, but they are highly derivate features, which eventually do not even manifest in some ethnographic populations.

Apart from the specific model considered, the various approaches reported here argue that BM was reached by different human populations and species at different times and contexts (d´Errico & Stringer, 2011). Furthermore, the emergence of BM traits does not necessarily follow an incremental, uni-linear trajectory connecting the Middle Paleolithic/ Stone Age record to the Upper Paleolithic one. In contrast, it follows multiple cultural trajectories that often show a patchy distribution of new behavioral traits, characterized by discrete events of emergence and possibly loss of innovations before their full consolidation in the archaeological record (Hovers & Cohen, 2006). Environmental factors related to climatic shifts (d´Errico & Banks, 2013), effects of population size on mechanisms of cultural learning (Powell et al., 2009; Shennan, 2001), the active role of cultural values in accepting innovations (Gelfand et al., 2011) and the construction of appropriate learning environments (Sterelny, 2011) represent critical factors for the rise of BM traits in both modern humans and Neanderthals. In this way, Early Upper Paleolithic behaviors could manifest in *both* sides as the product of ecological tensions created by the interaction between modern human incomers and native Neanderthal populations (d´Errico, 2003, his emphasis). Conversely, they could be related to reasons intrinsic to the very Neanderthal world (Zilhão, 2007). In any case, the emergence of BM has to be sought in the relationship between cultural phenomena and ecological niches (d´Errico & Banks, 2013), rather than in innate biological differences between human species. In fact, the roots of modern cognition lie in the Middle Pleistocene, prior to the split of Neanderthals and modern humans (d´Errico & Stringer, 2011; Zilhão, 2007, 2011a).

2.4 - Cognitive pluralism

Although cognitive equivalence models are receiving growing support, their conclusions are not univocally shared and several authors currently defend pluralistic models for the evolution of human cognition. Mithen (1994, 1996, 2014) claims that the modern human Upper Paleolithic material culture can be produced only as a result of some event of biological change within the mental/neural architecture. By referring to models in evolutionary psychology (Barkow et al., 1992) and in particular to Howard Gardner´s (1983) multiple intelligence theory, he depicts a model for the evolution of mental architecture that resembles the construction of a cathedral. Mithen contends that human cognitive evolution is grounded into a mechanism of incremental addition of hard-wired cognitive modules (i.e., the chapels of the cathedral). Starting from a module for general intelligence that humans share with apes, additional specific modules, dedicated to natural, technical, social and linguistic intelligences gradually emerged during human evolution. Early modern humans and Neanderthals are characterized by a mental architecture constituted by the same chapel-modules that characterize fully modern humans. However, only Upper Paleolithic humans are provided with a central meta-cognitive module, which allows the communication between the other domain-specific modules, like a central super-dome that operates a connection between the side chapels. In this way, Mithen (1996, 2014) claims that the modern human Upper Palaeolithic material culture constrains the existence of such a cognitive architecture, whereas the same does not apply to Neanderthal material culture.

In contrast with this qualitative reorganization thesis, Wynn & Coolidge (2004) apparently argue that Neanderthals and fully modern humans share the same mental architecture. In their view, however, a small alteration in some quantitative aspects of this architecture produced (and in turn is necessary to explain) the flourishing technological innovations that characterize the Upper Palaeolithic. These authors (Coolidge & Wynn, 2004, 2009; Wynn & Coolidge, 2011) claim that an adaptive genetic mutation increased the capacity of some modules within the working memory architecture (Baddeley, 2003), namely the central executive and the phonological loop. An augmented capacity in the former could have provided modern humans with more advanced executive functions, like planning, cognitive control/inhibition, manipulation of abstract categories, etc. An enhancement in the latter, instead, could have produced a new linguistic mode, namely the subjunctive "what-if" speech, which could generate deeper autonoesis, mental time travelling and inter-modular integration (Carruthers, 2002). Such biological augmentations are considered to be necessary for the emergence of long-term plans, like the intentional burning of grass finalized to maximizing resources the year after (Lewis, 1982), which characterize modern human thinking and has no counterpart in more archaic populations.

The previous proposals, albeit different in the theoretical models they draw from, seem to share the same epistemological bases. Indeed, they are grounded into the analysis of the archaeological record and the definition of the mental properties that are necessary to produce artifacts. This analysis contextualizes the discussion about cognitive processes (and the differences that exist between various species/populations) within a theory of mental architecture. Most importantly, this epistemological approach appears to be deeply grounded in the analytic categories and the theoretical background of cognitive science. The same does not apply to the cognitive equivalence models, which are mostly focused on the identification of conditions for BM in the archaeological record. In contrast, BM seems to play a limited (if any) role in the cognitively-oriented models. In consequence, the sharp divergence in the theoretical conclusions reached points to the epistemological inconsistency of these proposals.

3. Objectives

The current thesis is organized in three main parts. Part one analyzes the epistemological foundations of cognitive archaeology. It purposes to introduce a methodology to map the archaeological record with the properties of neural and mental architectures that is grounded in the conditional principles of a processual cognitive archaeology (e.g., Renfrew, 1994), though adopting some aspects of the interpretive, post-processual approach in knowledge acquisition (VanPool & VanPool, 1999). Such a methodology, called "holistic mapping", aims to provide a tool for the rational selection of theories in this domain.

The principles of holistic mapping will be applied to the debate about Neanderthal cognitive equivalence. It will be shown that the current disagreement between supporters of equivalence and partisans of pluralism does not emerge from different theoretical explanations about modern human and Neanderthal cognition. On the contrary, disagreement is caused by the adoption of incommensurable epistemological foundations. In particular, the Neanderthal cognitive equivalence agenda improperly adopts a notion of behavioral modernity to connect behavioral practices reconstructed in the archaeological record with a modern mental architecture. A series of epistemological and metaphysical arguments will be provided in order to support a philosophical elimination of this notion from the cognitive archaeological domain.

Part two applies the conditional principles previously developed to the practice of early body adornment. The emergence of shell-beads in the archaeological record of Neanderthals has been considered as an instance of fully-symbolic *Homo sapiens* behavior (Henshilwood & Marean, 2003) that proves the cognitive equivalence of Neanderthal populations (Zilhão, 2007). A radical embodied approach will be employed to argue that early body ornaments do not necessarily require signature properties of modern cognition, like theory of mind and abstract conceptualization (Henshilwood & Dubreuil, 2009, 2011). In contrast, early body ornaments could be explained by means of direct social perception of embodied emotional reactions. Since this ability appears prima facie compatible with a primitive mental architecture (Barnard, 2010a), cognitive equivalence between ornament-makers and contemporary human populations is no longer warranted.

In the third part, it will be shown that the principles of human cognitive becoming formulated by material engagement theory (Malafouris, 2013; Malafouris & Renfrew, 2009) provide additional arguments against considering early body ornaments as a proof of symbolism and cognitive modernity.

Overall, a combination of principles form conditional cognitive archaeology, radical embodied cognitive science and material engagement theory will be used to counter a core tenet of the cognitive equivalence agenda. This thesis will ultimately show that the presence of early body ornaments in the Neanderthal archaeological record is currently unable to support cognitive equivalence with modern humans. By these lights, empirical arguments that attempt to defend Neanderthal innovation and the independent production of early body ornaments (e.g., Zilhão, 2012) become unsupportive of the cognitive equivalence thesis. For Neanderthals could have developed body ornaments along an archaic trajectory of cognitive evolution.

4. Results and discussion: epistemology

4.1 - Holistic mapping

Historically, cognitive archaeology had to confront two epistemological problems. On the one hand, the extinct mind represents a problematic object of science, for it cannot be directly investigated within the archaeological record. The lack of inductive inference and direct empirical falsification of theoretical hypotheses fostered "scientific pessimism" towards the possibility for such a research program (Binford, 1965). In particular, the same behavioral practice identified in the record could be compatible with different cognitive explanations, thus impeding a direct empirical selection of alternative theories. On the other hand, post-processualism fostered an interpretative archaeology based on subjective reconstructions of meaning for the archaeological record. Abandoning the search for a positivistic method in archaeological theory, this movement opened to hyper-relativistic drifts and allowed situations where "anything goes" (Bell, 1994).

The current thesis purposes to overcome these problems by providing a new method for theory validation in cognitive archaeology, which has taken the name of "holistic mapping" (Garofoli 2013a, Garofoli, forthcoming; Garofoli & Haidle 2014,). This method is grounded in some of the core tenets of a processual/conditional cognitive archaeology (Abramyuk, 2012; Bell, 1994; Renfrew, 1994; Wynn & Coolidge, 2009). It assumes that the scope of this discipline is to analyze behavioral practices in the record and map them onto the minimal necessary and sufficient conditions to realize them at the cognitive level.

The application of holistic mapping to the most broadly adopted example of "fully symbolic sapiens behavior", namely the use of shell-beads as ornaments, can be used to illustrate the principles of this method. Holistic mapping is divided in several stages. First, the method assembles behavioral architectures from the analysis of the interactions between hominins, artifacts and environment reconstructed from the archaeological record (Barnard, 2010b; Haidle, 2009, 2010; Lombard & Haidle, 2012). Shell-bead ornamentation systems are described as networks of human-artifact-human interactions that develop within a social scenario. Semiotic analysis is applied to such behavioral architectures to highlight the construction of meaning (i.e., which kind of information is attached to shell-beads and how) and social understanding (i.e., how social agents understand the relationship between shells and their meaning). A motivational dimension is added in order to define why shells acquire social relevance and deserve to be turned into body ornaments. Then, cognitive properties that are minimally required to explain the different levels that constitute shell-bead adornment are defined. Such necessary cognitive conditions are contextualized within a theory of mental architecture. Different cognitive explanations that are all compatible with the archaeological record are deduced from this level. In a second, abductive stage, the cognitive explanations formulated for a single behavioral practice are contrasted with a network of theories related to the entire behavioral repertoire of one species of hominin. In this way, the candidate explanations for shell-bead adornment are compared with those produced by the analysis of additional behavioral practices in the record, as for example the use of adhesives as a component for hafting (Wadley, 2010), the production of Levallois flakes or simple burials. From this holistic procedure, the mental architecture that is minimally required to produce all these practices is selected as the most plausible explanation. By contrast, explanations that represent unique cases, are not well integrated with the rest of the hypothesized cognitive requirements and can be superseded by more plausible explanations are ruled out as unnecessary. For example, shell-bead body ornaments could be compatible with advanced cognitive abilities that are not required to explain the rest of a hominin´s material culture. On the other hand, these body ornaments could be also consistent with a minimalistic explanation that better fits with the network of theories already in place. Higher stability within a network of theories allows one to prefer the minimalistic explanation over the discordant one. The holistic selection of theory therefore represents a form of post-processual hermeneutics, where the interpretative context itself is critical for the selection of the most plausible theoretical positions (VanPool & VanPool, 1999). Unlike post-processualism, though, such a method focuses on the interpretation of "how" artifacts mean rather than of "what" they mean.

This method solves the problem of selecting among multiple explanations that lies at the core of scientific pessimism. By adopting a holistic approach for theory validation (e.g., Godfrey-Smith, 2003, p. 31-34), it supersedes the necessity of embracing a strict one-to-one falsificationist logic. On the other hand, such a method is based on rational criteria for theory validation and thus it escapes also from subjective drifts. In this way, holistic mapping solves the impasse that characterizes cognitive archaeology, trapped between scientific pessimism and relativism.

4.2 - Behavioral modernity

An analysis of the epistemological foundations of cognitive archaeology has revealed that this domain is plagued by deep problems. The inferential methods commonly adopted in cognitive archaeology are indeed incommensurable with the logic of holistic mapping (Garofoli, 2013a; Garofoli & Haidle, 2014) and more in general with a conditional cognitive archaeology (Abramyuk, 2012, p. 30-33).

As repeatedly highlighted throughout the manuscripts that constitute this cumulative thesis (see Garofoli, forthcoming a), the key problem at the roots of incommensurability lies in the adoption of BM (or surrogate notions) as an epistemic tool for connecting properties of the archaeological record with properties of mental architectures. Indeed, BM has been used to categorize some artifacts as behaviorally modern on the basis of some criteria for modernity that are defined by lists of typical modern human behavioral traits or by "essentially modern" behaviors (sec. 2). Once a behavior in the record is considered to fit within the category of BM, a direct connection is performed from this level to cognitive modernity. The outcome of this inferential process is that every species whose behavior is classified as BM is also provided with a modern mental architecture. This approach is non-analytic, for the connection between modern behavior and cognition is indeed assumed a priori. Furthermore, the actual existence of such a connection is the very thesis that requires demonstration. Thus BM fosters logical circularity, leading to invalid conclusions (see sec. 4.6 for an application of these epistemic principles). In contrast, holistic mapping contends that any connection between artifacts and cognitive properties must *result* from an analytic process that examines behavioral architectures and connects them to necessary properties of mental systems.

4.3 - Behavioral modernity eliminativism

The previous epistemological critique would already suffice to ground skepticism toward the use of BM in cognitive archaeology. However, some previous attempts to criticize BM at the epistemological level were not decisive (Shea, 2011; Soffer, 2009) and literature is still replete of the use of this concept. In consequence, a critique of BM has required adopting a more radical approach. By employing the theoretical tools of scientific eliminativism (Machery, 2009, 2010), Garofoli (forthcoming a) has attempted to offer a "silver bullet" argument to undermine the scientific reliability of BM in cognitive archaeology. This work has provided a metaphysical analysis of the most broadly adopted concepts of BM, namely a list-based and an essence-based approach (Nowell, 2010). This analysis has shown that both the versions of BM fail to be considered natural kinds and hence cannot be the target of scientific analysis. BM at best could be maintained as a functional kind, namely as a concept that can play a useful role in the epistemology of cognitive archaeology. BM can survive as a functional kind only if considered to represent those "behaviors that could be produced by a modern mental architecture". However, this version of BM is redundant with the notion of cognitive modernity (i.e., *Homo sapiens* mental architecture) and becomes therefore irrelevant to the process of mapping artifacts and mental systems. In consequence, the notion of BM is metaphysically empty and epistemically numb. The only reason to maintain it in cognitive archaeology might be to facilitate communication between scholars in this field. However, the well documented misuse of this concept encourages eliminating it from the cognitive archaeology vocabulary.

4.4 - Neanderthal cognitive equivalence: epistemological problems

The principles of holistic mapping have been contrasted with the current methods of knowledge acquisition adopted by the Neanderthal cognitive equivalence agenda. The results of this analysis will be illustrated in the next sections by considering Zilhão (2007, 2011a, 2012) approach as an emblematic case study. On the one hand, these works focus on symbolism as a representative category for quintessentially modern behavior. In this way, they assume that the emergence of early body ornaments in some late Neanderthals sites (e.g., Zilhão et al., 2010, sec. 2.3) raise a strong case for Neanderthal cognitive equivalence. On the other hand, these papers represent a synthesis of the methods and tenets of the cognitive equivalence model (see the Introduction). Similar inferential steps and conclusions are also adopted by other works within this body of theory (e.g., d´Errico, 2003; d´Errico et al., 2003b).

4.5 - The "intuitionist" fallacy

Zilhão (2007, 2011a, 2012) reaches conclusions about Neanderthal cognitive equivalence by adopting inferential approaches that sharply depart from the epistemic requirements described in section 4.1. In particular, this author does not provide a semiotic analysis of how meaning is constructed for these ornaments. No behavioral architecture that represents this body adornment practice is assembled, nor is a conditional mapping of the necessary cognitive abilities to realize this behavior performed. In contrast, shell bead ornaments are a priori considered as symbols and symbolism as a proof of BM. The notion of BM is then improperly adopted to connect symbolism to cognitive modernity and to reject the existence of cognitive/biological differences between Neanderthals and modern humans. By the arguments raised in section 4.2, this approach stands as non-analytic and logically circular. In fact, the connection between early body ornaments and cognitive modernity is the actual point of enquiry and cannot be postulated a priori.

Presumably, such an invalid connection is driven by intuitions grounded in the perception of "complexity" (Garofoli, 2013a) in some behavioral practices. The search for BM as a condition of superiority in human material culture resonates with those behaviors that apparently show intricate patterns of interactions between humans and artifacts. Early systems of ornamentation are perceived as sufficiently complex to be proof of BM and thus of a modern mental architecture. Nevertheless, intuitions of this kind lead to formulate dogmatic theoretical outcomes that generate unproductive debates. It is therefore necessary to supersede them with analytic approaches that regain a rational methodology for theory validation.

4.6 - Circularity of the cognitive explanations

Zilhão (2007) raises the level of the discussion, by focusing more deeply on the cognitive abilities involved in Neanderthal symbolism. He attempts to show that symbolic abilities are not limited to the production of beads, but they are indirectly constrained also by behaviors like birch bark pitch hafting (Mazza et al., 2006) and burials (Grün & Stringer, 2000). Such behaviors are considered to necessarily require language and abstractions and to clearly show evidence of "enhanced working memory" that represents a signature trait of modern cognition (Coolidge & Wynn, 2005). Although the holistic approach attempted by Zilhão is commendable, these cognitive implications are again plagued by the absence of analyticity. There is in fact no obviousness in the connection between hafting practices and abstraction/language and any involvement of such abilities must be argued by assembling behavioral architectures and mapping them onto mental systems. The automatic connection between artifacts and "typically modern" cognitive abilities shifts the problem of circularity introduced earlier for BM to the cognitive level.

4.7 - A behaviorist problem

Additional problems arise when evidence for the emergence of early body ornaments by either independent innovation or conceptual transmission is considered as proof of modern cognition (sec. 2.3). This stance is valid only insofar as we commit to a behaviorist assumption, by neglecting the multiple nature of cognitive implementation for the production of behaviors (Garofoli, 2013a; Garofoli & Haidle, 2014; Mithen, 2014, p. 12). In contrast, according to multiple realization, it could be possible that the same behavioral practice could be realized, and thus appear in the archaeological record, by means of alternative cognitive strategies. Considering the process of conceptual transmission discussed by Zilhão (2007), Neanderthal beads could in fact be produced by a process of emulation that takes place from the observation of modern human ones (see also Coolidge & Wynn, 2004, on similar grounds). This would mean that Neanderthals at one end of the chain (the one proximal to the modern human presence in the Near East) could have learnt to produce the same behavioral outcome (i.e., beads) by means of alternative cognitive processes. These very processes could have led to the diffusion of beads throughout the Neanderthal world, until these artifacts reached the distal end of the chain. Crucially, such alternative abilities could require a different mental architecture than a modern human one. Hence no cognitive equivalence is proved by the conceptual diffusion mechanism described by Zilhão (2007).

4.8 - Upper Palaeolithic derivate behaviors

Partisans of cognitive equivalence (d´Errico, 2003; Villa & Roebroeks, 2014; Zilhão, 2007) seem to argue that the typical modern human behaviors are those appearing in the Mousterian (including in a loose sense also the Middle Stone Age industries). In this way, they assume that the Mousterian correlates with the presence of a modern cognitive architecture. In their view, evolved Aurignacian artifacts like figurative parietal art, musical instruments, ivory figurines (Conard, 2003, 2009; Conard & Bolus, 2003; Conard et al., 2009) are special, derivate cases of a BM acquired in the Mousterian period and thus of a shared mental architecture. These conclusions are advanced on non-analytic grounds. There is no a priori way to say that the cognitive properties used to create early body ornaments, Levallois tools, simple burials, etc. are equivalent to those necessary to produce therianthropic figurines, parietal arts or musical instruments. Any inference of this kind requires a conditional analysis of the necessary cognitive properties to realize these artifacts (Garofoli & Haidle, 2014, Garofoli, forthcoming a). Derivate Upper Palaeolithic technologies could necessitate of cognitive properties that require biological augmentation in Neanderthal and possibly even early modern human brain (R.G. Klein, 2009).

4.9 - Incommensurability

Overall, proponents of cognitive equivalence seem to miss the crucial scope of a conditional cognitive archaeology. This lies indeed in explaining *why* a modern cognitive architecture is necessary to produce early instances of body ornaments or behaviors that indirectly constrain symbolism (Wadley, 2001). The previous sections have shown that the cognitive equivalence agenda neglects to provide explanations about such conditions of necessity/sufficiency for the cognitive realization of behaviors. This problem manifests in a broad gamut of situations, ranging from the connection between behavioral and cognitive modernity, to the relationship between cognitive "complexity" and modern mental architecture (Garofoli, 2013a), up to the mechanisms of cultural transmission.

In principle, it is possible that the application of a proper analytic approach would ultimately lead to invalidate the equivalence thesis. Indeed, after the holistic mapping process is performed, a series of minimalistic cognitive abilities could explain behaviors commonly considered as proof of BM (e.g., body adornment and hafting), as well as their cultural transmission, without requiring a modern cognitive architecture. If so, the very existence of "modern behaviors" in Neanderthal material culture would be compatible with a primitive mind and fail to prove cognitive equivalence with modern humans.

Lack of analyticity affects also the majority of the cognitive equivalence criticism. Great part of the criticism to this model is based on disputing Neanderthal authorship for transitional industries in Europe (Bar Yosef & Bordes, 2010; Mellars, 2010; Benazzi et al., 2011; Higham et al., 2011; Nigst et al., 2013). This critique is however grounded on empirical arguments, whereas, at the theoretical level, the use of BM and its direct connection to modern cognition are left undisputed.

However, other critical approaches to the cognitive equivalence agenda resonate with the requirements of a conditional cognitive archaeology. In particular, the enhanced working memory project (Coolidge & Wynn, 2005, 2009; Wynn & Coolidge 2011) aims to defend a cognitive pluralist agenda by looking at the cognitive structures underlying modern human and Neanderthal material culture. Wynn & Coolidge (2004, p. 468) admit that their work starts from a priori intuitions of the kind that affect the cognitive equivalence agenda. They consider as a premise the fact that culture cannot explain the differences between modern human and Neanderthal archaeological record. Biological mutation is thus considered as necessary to explain this difference. However, this intuition constitutes a null hypothesis, which they aim to prove by mapping properties of the record onto cognitive processes and architectures (see also Mithen, 2014, p. 12 for a similar approach). These authors take into account Levallois reduction (Wynn & Coolidge, 2004), Chatelperronian blades (Coolidge & Wynn, 2004), hunting systems (Wynn & Coolidge, 2004), burials and early "symbolism" (Wynn & Coolidge, 2004, 2012). They map these processes onto Alan Baddeley´s (2003) working memory architecture and argue that these behaviors do not constrain the existence of cognitive fluidity, subjunctive linguistic forms and enhanced working memory capacity that are proper of modern human cognition (sec. 2.4). Most importantly, Wynn & Coolidge (2004) provide a series of conditions for enhanced working memory to manifest in the archaeological record. If such conditions appeared in Neanderthal material culture, the hypothesis of modern human cognitive enhancement would be disproved and no critical biological/cognitive difference would differentiate Neanderthals from modern humans, at least for what concerns working memory capacity.

Apart from the actual validity of the theoretical conclusions formulated by the cognitive equivalence critics, a crucial point emerges here at the epistemological level. These pluralistic models do not make use of the notion of BM to connect modern behaviors to mental architectures. Conversely, they are compatible with the principles of conditional and holistic cognitive archaeology. For these reasons, they currently stand as incommensurable with the cognitive equivalence model. In consequence, the apparent theoretical opposition that characterizes these models is actually the product of incommensurable epistemological approaches (Garofoli & Haidle, 2014). Such an incommensurability impedes a proper comparison of these candidate theories and generates stagnation within the debate. In principle, the cognitive equivalence agenda might succeed in disproving pluralistic theses. However, this requires to thoroughly rethink the epistemological foundations of such a proposal.

5. A radical embodied critique

5.1 - The "gannet approach"

A crucial aspect of a conditional cognitive archaeology lies in identifying cognitive properties that are minimally required to explain the archaeological record. Garofoli (forthcoming b) has tackled this search for minimalism by embracing a radical embodied agenda (Chemero, 2009; Di Paolo & Thompson, 2014; Favela, 2014; Hutto & Myin, 2013). The logic of the approach developed here can be illustrated by a concrete example provided by Chemero (2009). This author discusses the cognitive approach adopted by gannets, a family of seabirds (genus *Morus*), in their fishing strategies. Gannets are famous for their ability to dive from great heights and hit the surface of water at ca 100 km/h in order to catch fishes deeper than other seabirds can reach. In performing this action, gannets have to close their wings at the right moment before the impact with water surface. Referring to Lee & Reddish´s (1981) work, Chemero points out that gannets do not realize this behavior by calculating speed, acceleration, relative height and optimal opening point in a prior, mentalistic way. In contrast, they simply keep eyes on the ambient array and pick up the invariant relationships in the optic flow while moving through it. In other words, when the image of the water surface increases in size at a certain speed, gannets perceive water as a penetrable medium that affords diving. In this way, they close their wings at the right moment and solve the cognitive task.

This example has been developed as an integrative part of an epistemological approach to radical embodiment (Chemero, 2009), which is centered on placing an empirical bet on how far can situated/embodied activity explain cognition prior to necessarily require mentalistic explanations. It adopts the conceptual tools of ecological psychology (Gibson, 1966, 1979), like the direct perception of affordances and the exploitation of invariant properties in the environment, to supersede explanations based on internal representations and sub-personal computations. This approach shares the same grounds with the principle of cognitive economy expressed by Clark (2008). A cognitive strategy that involves mental representation of variables like speed, height, mass and acceleration, as a part of a decision-making process would certainly be more expensive than simply keeping the eyes focused on water surface, evaluating the right moment to close wings from the size of the approaching water surface.

Garofoli (forthcoming b) has provided a first structured application of radical embodiment as a principle of cognitive economy in cognitive archaeology (henceforth the "gannet approach"). This approach assumes as a rule of thumb that evolution tends to maximize the principle of cognitive economy (Clark & Chalmers, 1998). Thus, it builds organisms that exploit their embodied activity at their limits to solve adaptive problems, before adding new costly neural structures that allow manipulating representations. These principles apply also to human cognitive evolution. Behaviors that intuitively appear as complex in the archaeological record could have been produced by exploiting radical embodied strategies, rather than mentalistic or language-based ones. Crucially, such minimalistic strategies could be compatible with a primitive mental architecture. In this way, many aspects of archaic material culture would not necessarily require the critical components of a modern mind to be developed. Furthermore, as shown by phenomenological research, disembodied/mentalistic cognitive strategies are often not even primary in modern humans (de Bruin & de Haan, 2012; Gallagher, 2008; Gallagher & Hutto, 2008; Hutto, 2011). It appears therefore unreasonable to assume these abilities as primary when required to explain the archaeological record of extinct humans.

However, many scholars in cognitive archaeology ignore these requirements and currently consider the highest mentalistic cognitive processes as default explanations to account for Paleolithic populations´ cognition (Malafouris, 2013). The gannet approach purposes to reform this situation by introducing new normative requirements in the epistemology of cognitive archaeology. In line with Chemero´s (2009) agenda, radical embodied explanations ought to be preferred to high level mentalistic ones as long as they can reliably explain behavioral practices in the record. Likewise, primitive mental architectures that are compatible with such embodied strategies get priority over the more advanced ones.

5.2 - Radical embodied ornaments

The vast majority of the cognitive equivalence approaches has relied on invalid connections between shell-beads, symbolism, BM and modern cognition (sec. 4.5). In contrast, Henshilwood & Dubreuil (2009, 2011) have attempted to give analytic foundations to the cognitive equivalence agenda. They have taken into account body adornment in the early modern human Still Bay and Howiesons Poort industries dated at ca 77-59 kya. Focusing in particular on pierced shell beads, they have concluded that the use of similar forms of body ornaments entails the presence of abstract shared standards (like the concept of COOLNESS), which are identified in the mind of the conspecifics through high level mindreading. The involvement of these mentalistic strategies is sufficient to claim that the ornament-makers were provided with cognitive capabilities akin to those of contemporary populations. Such conclusions are general and thus they apply also to the case of Neanderthal ornaments (Zilhão, 2007, 2012; Zilhão et al. 2010).

Nevertheless, by applying a combination of the principles of holistic mapping and the gannet approach to the case of early body ornaments, Garofoli (forthcoming b) has contested the validity of the arguments advanced by Henshilwood & Dubreuil (2011). This work has analyzed the body adornment phenomenon through the multiple dimensions discussed in sec. 4.1. A semiotic approach has allowed dividing body adornment in three different classes, according to how meaning is constructed by both the initiator of the practice and the communicative targets. Drawing from Peirce (1931-1936), this division has followed a basic triad of aesthetic/iconic, indexical and symbolic body ornaments. Behavioral architectures have been assembled by combining the construction of meaning with a motivational dimension, which specifies the reasons for turning an object (e.g., a shell) into a body ornament for each of the three classes. In contrast with many works in cognitive archaeology, which focus on body adornment as a static, finished set of practices, the instantiation of body adornment has been described along a process of cultural development. Each class of body ornaments has been examined across various phases, namely the initiation, understanding and maintenance of the practice. These enriched behavioral architectures have been then mapped onto cognitive properties by following the gannet approach. In this way, radical embodied strategies have been adopted as primary tools to explain the three classes of ornaments.

The integration between these multiple levels has been performed by providing phenomenological thought experiments. The result of this analysis has led to the definition of normative conditions for each class of ornaments, which have been ultimately adopted to analyze Palaeolithic shell-beads.

5.3 - Key results

a) **Non-symbolic ornaments**: The gannet approach succeeds in explaining non-symbolic classes of body ornaments. In particular, phenomenological analyses show that aesthetic and indexical meanings can be grounded in the direct perception of social affordances (de Bruin et al., 2011; Gallagher, 2008; Hutto, 2008, 2011). Some rare items are characterized by configurations of invariant features that make them "special" (e.g., the shiny reflections of gold nuggets). When collected and showed to some viewers, these objects can become the focus of emotional reactions. Agents learn to discriminate the meaning of positive emotional reactions towards aspects of the world from previous episodes of social engagement. Therefore, the meaning of the object can be directly perceived in the relationship between the agent´s hand-holding-object and the embodied emotional reactions of the viewers towards it. Special objects actively provide social affordances (i.e., afford-charmability) and motivate agents to keep them permanently attached to their body (e.g., through the use of strings). In this way, objects are gradually turned into body ornaments. In a first moment, these ornaments produce new body icons, by changing the perceptual appearance of an individual´s body. Due to their rarity, these ornaments can become indexical of the ability to procure them, so that the wearer is also perceived as wealthy, powerful, etc. On the long term scale, such "extended phenotypes" and their embodied emotional implications shape a context of social norms. A form of social "narrative" emerges from the set of embodied relationships marked by the use of artifacts. Future generations are thus directly embedded in this context and learn to perceive adorned individuals as relevant, on the ground of directly perceivable emotional reactions.

b) **Elimination of mentalistic strategies**: The radical embodied explanations discussed above eliminate the need for the high level mentalistic strategies proposed by Henshilwood & Dubreuil (2011). Emotional reactions stand by themselves as the meaning of the object and rule out the need to represent in mind abstract concepts and a priori impose them to the ornaments. Furthermore, if meaning can be directly perceived in embodied action, there is no need to detect it in the viewers´ mind by means of high level-theory of mind. Hence, no explicit knowledge of abstract meanings needs to be ascribed to the ornaments and shared at the social level.

c) **Full-symbolism**: The gannet approach fails to explain the semiotic category of full-symbolism. This class taps into a level of abstraction that entails the involvement of linguistic vehicles and theoretical concepts. As the cases of body adornment in critical subcultures and political emblems show (Garofoli, forthcoming b), meta-representational abilities are necessary to ascribe meaning to these signs and share it at a social level. In this way, Henshilwood and Dubreuil´s (2011) requirements apply to the category of full-symbolism.

5.4 - Body ornaments and Neanderthal cognitive equivalence

The previous analysis has been applied to the problem of early body ornaments in cognitive archaeology. This has led to conclude that the use of shell-beads can be thoroughly explained as a form of aesthetic or, at most, indexical body adornment. In consequence, this practice can be explained by means of radical embodied tools and does not necessarily entail the high-level mentalistic requirements postulated by Henshilwood and Dubreuil (2011). Since these latter requirements were considered as a signature property of modern cognition, the gannet approach operates a disconnection between the existence of these artifacts in the archaeological record and the cognitive equivalence of their makers with contemporary modern humans. In this way, Neanderthal cognitive equivalence does not necessarily follow from the presence of shell-beads (Zilhão et al., 2010) or comparable body ornaments (Morin & Laroulandie, 2013; Peresani et al., 2011) in their material culture

However, the current argument developed by Garofoli (forthcoming b) has mostly acted in *pars destruens*, by excluding the involvement of high-level cognitive properties like theory of mind and abstract conceptualization from the use of early body ornaments. The embodied strategies discussed here ought to be contextualized in a theory of mental architecture in order to assess what kind of organization is necessary to justify these cognitive requirements. At date, lacking an analysis of this macro-level (Barnard et al. 2000; Garofoli & Haidle, 2014) within the holistic mapping procedure, no conclusive argument can be safely advanced about the minimal cognitive organization required by early body ornaments. It might be the case that the radical embodied processes described here still entail a modern mental architecture to be realized. However, preliminary theoretical research on the relationship between mental architectures and early body ornaments hints differently.

6. Cognitive architecture: a preliminary analysis

A first analysis of Barnard´s (2010a) interacting cognitive subsystems (ICS) model of cognitive architecture (see Garofoli & Haidle, 2014 for brief illustration) seems to suggest that early body ornaments do not require a modern mind to be produced. Barnard´s 9-ICS architecture focuses on the emergence of an additional cognitive loop for the processing of meaning in modern humans compared to the more archaic 8-ICS architecture. This additional loop entails the possibility for linguistic propositions to be not only bound with sensory-motor content, but to be themselves used to build a new level of content. Abstract concepts that have no immediate referents in the world could be thus represented by structures of words. In particular, definitional concepts based on normative conditions (Smith & Medin, 1981), or theoretical ones represented by networks of causally related events (Rehder, 2007) can thus emerge through this new level of meaning. Likewise, the implicational loop makes possible to represent propositional attitudes towards a concept and thus it allows to acquire a meta-representational perspective of the kind "I know that you believe in X" (mindreading) or "I know that I wish Y" (reflective or autonoetic mindreading).

Such a mental architecture appears therefore as crucial to the abilities postulated by Henshilwood & Dubreuil (2011). On the other hand, it stands as prima facie unclear how Barnard´s (2010a) implicational loop necessarily applies to the radical embodied processes proposed by Garofoli (forthcoming b). The ICSs model is based upon conservative embodied principles (Hutto & Myin, 2013, p. 9-15), since it maintains the distinction between perception and action and the performance of sub-personal computations by multiple modules. However, the general organization of this architecture is relevant to analyze the radical embodied processes introduced above. Embodied direct perception seems to be grounded into a combination of spatial-praxic abilities and mnemonic components. A positive emotional reaction towards a shell held in the hand is directly perceived when the invariant properties of this action enter in resonance with previous memories of similarly directed emotions. In the grounding of meaning described by the radical embodied approach there is no clear trace of meta-representational abilities or high level abstractions that would require an implicational loop to be produced. It might be the case that such abilities are involved in the process of decision-making required to turn a relevant object into a body ornament. However, cognitive abilities that are compatible with an 8-ICS architecture, namely the intentional towardness of attention, situated simulations and memories, coupled with forms of paralogical reasoning (Huttenlocher, 1968) and supported by basic linguistic syntax, appear sufficient to tackle this decision-making process. Nevertheless, further theoretical research is required to clarify this point.

The current analysis of early body ornaments is still in the initial stage of the holistic mapping process. Once a mapping of the radical embodied processes described here is performed within a theory of mental architecture, the candidate conclusions advanced need to be contextualized within a network of theories (sec. 4.1). This network represents the minimal cognitive explanations derived by the similar analysis of other "intuitively modern" technologies that appear in Neanderthal archaeological record. Special attention ought to be provided to the case of birch bark pitch hafting, considered by Zilhão (2007) as a proof of cognitive equivalence in Neanderthals. Once the link between early body adornment and signature properties of modern cognition is eliminated, the existence of a similar connection between hafting technologies and modern cognition does no longer stand as obvious.

7. Cognitive becoming

7.1 - Material engagement

The second part of this thesis has shown that early body ornaments do not constrain full symbolism, nor do they entail the cognitive abilities required to process this semiotic class. Besides this dimension of conditional requirements (i.e., the cognitive being), the symbolic character of early body ornaments has been contested also at the level of the human cognitive becoming.

Material engagement theory (Garofoli 2013b; Malafouris, 2013) claims that symbolism is not an intrinsic property of an evolved modern mental architecture. Thus, it cannot be somehow "revealed" by variations in demographic or environmental conditions (Ambrose, 1998; Lahr & Foley, 1998), nor can it be abruptly acquired by the mere exposition to new particular stimuli. In contrast, symbolic meaning has to be enacted through a stage of engagement with non-symbolic artifacts. Thus, the engagement with non-symbolic material scaffolds stands as a necessary condition to drive a process of semiotic metamorphosis. For example, the use of gold nuggets as aesthetic ornaments (Garofoli, forthcoming b) is necessary to bring forth the indexical relation between wearing gold and being wealthy (sec. 5.3). On the long term scale, such an indexical relation can scaffold the emergence of symbolic relationships that conventionally connect gold with abstractions like money, value, market, capitalism, etc. Such transformative principles apply also to the cognitive level. Symbolic cognitive abilities, like full-blown mindreading and abstract conceptualization (Henshilwood & Dubreuil, 2011) cannot be acquired by mutational enhancement or brute exposition to environmental stimuli. They must be brought forth by means of a transformative process that builds on the radical embodied strategies required to minimally make sense of body adornment (Garofoli, forthcoming b). In human evolution, like in ontogeny, embodied emotions directed towards artifacts become the target of linguistic vehicles (see Barsalou et al., 2008, for a description of a similar mechanism). Provided that the cognitive architecture in consideration has sufficient degrees of freedom to accommodate such a transformation, words are used to produce progressively more sophisticated abstractions. A positive emotional reaction toward an ornament could offer a perceptual basis to ground an abstract concept of BEAUTY (Barsalou, 1999), which can be used later to produce fully symbolic ornaments. Furthermore, the growing complexity of social contexts could generate a certain degree of ambiguity in the direct perception of embodied emotional reactions. In consequence, humans could attempt to tackle this problem by applying language to clarify the relationships between social agents and aspects of the world. They could thus adopt language as a tool to represent other people´s beliefs (see the notion of meta-representation in section 6). Direct social perception of emotional reactions allows one to spell out the relationships that become the target of language and meta-representations. In this sense, this embodied ability becomes a means for the acquisition of a disembodied theory of mind.

In cognitive archaeology, the necessity for a semiotic/cognitive metamorphosis imposes that traces of such a transformative process must be identified in the record for any presumable case of symbolism. In the case of modern humans, for example, it could be argued that the emergence of artifacts like the lion-man ivory figurine (Wynn et al., 2009) constrains the presence of symbolic abilities. According to Abramyuk (2012), this artifact entails the capability of processing four orders of intentionality (e.g., I know that you know that I know that the gods know), which are considered to be crucial in the construction of fully symbolic meaning. The emergence of symbolic artifacts in modern humans could be scaffolded by millennia of social interactions mediated by non-symbolic body ornaments like shell-beads, which have deep roots in the African MSA (d´Errico et al., 2009; McBrearty & Brooks, 2000). Lacking clear evidence for such a transformative process, Neanderthal shell-beads ought to be considered as belonging to the first stage of material engagement. Since this stage is preliminary to the emergence of full-symbolism, Neanderthal beads currently represent evidence *against* symbolism.

Disproving this reasoning requires identifying instances of material scaffolding in the Neanderthal record prior to the emergence of pierced shell beads in transitional industries. This evidence could be used to displace back the whole process of cognitive metamorphosis and argue for a fully-symbolic character of shell-beads. Currently, the soundest strategy to support an earlier transformative process lies in assuming that some practical abilities (e.g., hafting) scaffolded the emergence of symbolic beads in late Neanderthal populations. This argument is grounded into two core assumptions. First, such practices necessarily require the existence of the same "symbolic" abilities necessary to produce fully symbolic ornaments (sec. 5.3c). In this way, the cognitive processes used to build meaning for words suffice to ground meaning for material symbols. Second, such abilities, involved in the performance and transmission of practical tasks, are transferred to another domain, namely that of communication through material culture. In other words, late Neanderthal populations adopted their linguistic knowledge, acquired in the production of tools, to create a theoretical social scenario, which defines a series of relationships between agents, mediated by artifacts. This mental construct is eventually imposed to reality and shaped as a system of body ornamentation (but see Malafouris, 2013, p. 237 for a critical view on a similar point). In both the cases introduced above, the onus of the proof is on supporters of cognitive equivalence.

7.2 - Biological constraints to cognitive transformation

Garofoli (2013b) has highlighted a potential pitfall with the current formulation of material engagement theory. The engagement with material scaffolds is a necessary condition to enact new levels of meaning, as well as new cognitive abilities (Malafouris, 2007, 2013). On the other hand, this does not imply that material engagement is also a sufficient condition to justify this process of cognitive transformation. Referring to Malafouris´ (2013) example of Acheulean tool-making, the engagement with tools allows bringing forth mental templates of Acheulean tools and gradually leads human agents to think about thinking about these templates (i.e., acquisition of meta-representations). However, this cognitive transformation does not necessarily happen in every human agent that is engaging with Acheulean tools. It is in fact conditioned by the existence of innate constraints within the neural and bodily systems. This argument applies also to the case of Neanderthal body adornment and raises important questions about the topic of cognitive equivalence. The fact that Neanderthals might have started a process of cognitive transformation by producing shell bead ornaments does not imply that such process can be brought forth in the same modern human fashion. As preliminary considerations suggest (sec. 6), the use of early body ornaments could be compatible with an archaic mental architecture. It is thus possible that biological limits in this primitive architecture could have prevented Neanderthals from developing a fully symbolic level of meaning. Indeed, the acquisition of fully symbolic artifacts would imply the existence of a neural architecture that is capable of hosting meta-representational abilities. In other words, Neanderthals could have produced early body ornaments by moving along a different cognitive evolutionary trajectory than modern humans. They could have done this by exploiting radical embodied cognitive strategies at their limits, reaching levels of efficiency that are potentially higher than those of modern humans (Langbroek, 2012, 2014). Modern humans, on the contrary, provided with the higher degrees of freedom of a 9-ICS architecture, could have used early body ornaments as scaffolding for the emergence of meta-representations. They could have brought forth fully symbolic meaning along a trajectory that connects early body ornaments with ornamental iconic figurines, therianthropy and then religious idols. No doubt that inter-related multiple factors, including climatic shifts, environmental variations, population growth, new social assets and cultural dynamics could deeply affect cultural trajectories and innovations in Neanderthal and modern human populations (d´Errico & Banks, 2013; Sterelny, 2011, chapter 3). However, such conditions have effects on *both* primitive and modern mental architectures, leading therefore to cultural trajectories that are constrained by different cognitive limits.

Demographic, environmental and cultural dynamics are by themselves insufficient to add new biological components to mental architectures (Garofoli, 2013b). Therefore, to enact fully symbolic and meta-representational abilities, Neanderthals could have still required mutational enhancement in some aspects of their neural architecture (Haidle et al., 2015). In consequence, cognitive enhancement cannot be ruled out from the list of mechanisms assumed to explain variations within material culture in relation to changes in the ecological niches of extinct populations (Banks et al., 2013). d´Errico & Banks (2013, p. 383) have recently opened to the possibility of a future inclusion of cognitive/biological components in the study of eco-cultural niches variation, although referring only to a list of quantifiable traits that connect genes with attitudes, rather than to the conditional mapping of material culture onto mental architectures.

The fact that Neanderthals were "starting to produce their own Upper Paleolithic material culture" (d´Errico, 2003) is often used to draw inferences about their cognitive equivalence with modern humans. This defense, however, is plagued by a problem of logical circularity. It assumes indeed that identity of a single part of the transformative process warrants identity of the whole process. Thus, if both Neanderthals and modern humans were capable of producing similar Mousterian techno-complexes, then they were also both capable of producing evolved Aurignacian artifacts (Conard & Bolus, 2003), or even pen-drives or computers (Bruner & Lozano, 2014). However, whether Neanderthals had the cognitive capabilities to produce these derivate artifacts is the point of enquiry and cannot be assumed as a premise of the argument by direct analogy with modern humans. A conditional, holistic approach is required again to tackle this problem. The components of a modern cognitive architecture, for example Barnard´s (2010a) 9-ICS, must leave trace in Neanderthal material culture. Only at this point could it be argued that Neanderthal processes of material engagement could have developed on the same modern human grounds.

8. Conclusions and future developments

The arguments developed in this thesis have dramatic implications for the debate about Neanderthal cognitive equivalence. The reappraisal of a conditional approach in cognitive archaeology, supported here by the new methodology of holistic mapping and coupled with a radical embodied agenda, has shown that early body ornaments do not necessarily constrain signature properties of modern human mental architecture (in line with Mithen´s, 2014, preliminary analysis). The possibility that body ornaments could be compatible with an archaic mind is strengthened by initial analyses of Barnard´s (2010a) model. If these hints will be confirmed, then the validity of some empirical arguments for Neanderthal cognitive equivalence would be weakened. At present, a consistent part of the archaeological debate is focused on establishing whether Neanderthals were the makers of transitional industries and whether they produced these technologies as a genuine form of innovation (Bar-Yosef & Bordes, 2010; Caron et al., 2011; Higham et al., 2011; Mellars, 2005; Zilhão, 2014). Critics of the cognitive equivalence argument use paleoanthropological and archaeological evidence to claim that either modern humans produced those industries or Neanderthals became acculturated by interacting with moderns (Higham et al., 2014). The theoretical arguments proposed in this thesis open to a third possibility. Neanderthals could have produced transitional industries and early body ornaments by means of a primitive mental architecture. In this way, *even* the case of independent innovation would not prove the cognitive equivalence with modern humans. Conversely, innovation will show that Neanderthals developed early Upper Paleolithic technologies by moving on a different trajectory of cognitive evolution and material engagement. Clarifying the differences between these two trajectories, by focusing on the relative cognitive advantages and disadvantages within both sides (what Langbroek, 2012, defines different "cognitions"; see also Mithen, 2014) represents an important target for future research.

The rise of a pluralistic perspective would shift the focus of the debate from the problem of "absolute equivalence" between the two species, to the role cognitive differences actually exerted in the Neanderthal demise. The explanations concerning such a role are constrained by multiple empirical levels. Paleoanthropological evidence is indeed crucial to establish the entity of the interactions between modern and Neanderthal populations in Europe. A significant spatio-temporal coexistence of these populations could give credit to the hypothesis that modern humans displaced Neanderthals by competing more efficiently for resources, due to their more flexible cognitive abilities. On the contrary, a negligible contact related to low demographic densities in the Upper Paleolithic, or even the more extreme idea of a modern human expansion into Neanderthal "graveyards" (i.e., areas abandoned prior to the modern human income; see Finlayson, 2004), leads to rethink the causal role of cognition. Rather than providing competitive advantages, modern humans could have exploited their cognitive potential to adapt to environments where Neanderthals had previously failed. On the other hand, archaeological data are also crucial to understand the role of cognition in Neanderthal extinction. A direct technological advantage over Neanderthal populations can be supported only by showing an early development of evolved Aurignacian artifacts in modern human incomers (Higham et al., 2011). In contrast, if modern humans entered Europe with Mousterian technology and developed the evolved Aurignacian culture only after Neanderthal extinction (Zilhão, 2014), cognition could have represented at best an indirect reason for Neanderthal replacement. An equivalence agenda could survive by attempting to demonstrate that environmental or demographic factors unrelated to human cognitive activity were the primary cause of population shrinking in Neanderthals (Finlayson, 2009; see also Sterelny, 2011, section 3.5). Furthermore, since cognition ought to be considered as a transformative process driven by material engagement, partisans of equivalence could attempt to argue that modern humans started to exploit their implicational/meta-representational loop (Barnard, 2010a) only after the Neanderthal disappearance. This will raise the possibility for a "relative" cognitive and technological equivalence at the time of modern human incoming in Europe.

Nevertheless, much multidisciplinary work is still necessary to clarify the entity and the dynamics of the interactions between modern humans and Neanderthals in Europe before reliable conclusions can be advanced. Given the deep entwining of environmental, social, demographic and cultural aspects that characterize human life (d´Errico & Banks, 2013), the search for single factors likely represents a sterile approach in explaining the Neanderthal demise (Harvati, 2007, p.1737-1739). However, the present thesis has shown that cognitive reasons currently cannot be ruled out from the list of potential factors. Alterations in neural and cognitive architectures could have provided modern humans with higher degrees of freedom in their trajectory of cognitive transformation (Garofoli, 2013b), warranting at least indirect advantages over Neanderthals.

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Appendices

Publications Included In Fulfillment Of The Requirements Of This Cumulative Dissertation

A. Accepted works

A.1

Garofoli, D. & Haidle, M.N. (2014). Epistemological problems in cognitive archaeology: An anti-relativistic agenda towards methodological uniformity. *Journal of Anthropological Sciences*, *92*, 7-41.

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Epistemological problems in Cognitive Archaeology: an anti-relativistic proposal towards methodological uniformity

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Summary - *Cognitive archaeology (CA) has an inherent and major problem. The coupling between extinct minds, brains and behaviors cannot be investigated in a laboratory. Without direct testability, there is a risk that theories in CA will remain merely subjective opinions in which "anything goes". To counter this risk, opponents of relativism originally argued that CA should adopt a method of validation based on "indirectly" testing inferences from the archaeological record. In this paper, we will offer a two-part analysis. In the first part, we will discuss problems with the original anti-relativistic agenda. While we agree with the necessity of developing a rational methodology for this discipline, in our view previous analyses have significant weak points that need to be strengthened. In particular, we will propose that "indirect testability" should be superseded by a methodology based upon deductive mappings from networks of theories, followed by a plausibility-selection stage. This methodology will be implemented by adopting an extension of Barnard´s (2010b) proposals for mapping hierarchical systems. In the second part, we will compare our methods with those currently adopted in the CA debate. From this analysis, it will emerge that some proposals in CA are inconsistent with our methodology and are incommensurable with those that are consistent with it. Furthermore, we will show that theories in CA can advance contradictory conclusions precisely because they have been developed using different methods. We conclude that a universal methodology, like that proposed here, is needed for CA to become more objective. It is also crucial for creating conditions for coherent and productive debate among different schools of thought in the field of cognitive evolution.*

Keywords - *Cognitive archaeology, Epistemology, Incommensurability, Theoretical Mapping.*

Introduction

Twenty years ago cognitive archaeology (CA) emerged out of the Processual school and sought to distance itself from the subjective/interpretative approach adopted by the post-processualists. Interpretations were considered to be explanations open to manipulation that would have served to align an analysis of the archaeological record to the authors´ views. The interpretations could not be evaluated for how well they account for the target phenomenon on any objective criteria. Indeed, analyses were limited to *ad hominem* and "inside" methods. In order to be able to interpret the archaeological record, investigators typically relied on their own subjective experience to situate themselves within the envisioned physical or social contexts of distant pasts, (Hodder, 1984, 1986, 1987; Johnson, 1999, Chapter 7; Trigger, 2007, Chapter 9-10; Shanks

& Tilley, 1987a,b; see also Binford, 1987). The pioneers of cognitive archaeology criticized this approach as a form of opinion, based only on personal likes – it was "as wished for" archaeology (Renfrew, 1989, 1994; Bell, 1987, 1991, 1994a). The shared aim of these pioneers was to produce a methodology, with a clearly defined set of rules, to enable assertions about prehistoric cognition to be systematically tested.

The original epistemological objectives gradually faded into the background as new theories, deeply different in form and content, were developed to provide explanations about the evolution of mind and the emergence of behavioral practices considered unique to modern humans. Several frameworks, ranging from evolutionary psychology (Mithen, 1996) through cognitive neuroscience (Coolidge & Wynn, 2005; Wynn *et al.*, 2009; Wynn & Coolidge, 2011) to computational theory (Barnard *et al.*, 2007; Barnard, 2010a), were proposed to account for the properties of human mind and behavior (see Davidson, 2010 for review). These approaches, while grounded in different specific conceptions of the mind, nonetheless shared a common concern with providing cognitive/biological mechanisms underlying behavioral enhancements. A quite distinct tradition, rooted in the archaeological domain, sought to explain the same enhancements purely on the basis of socio-cultural interactions between individuals, without reference to biological constructs (d´Errico & Stringer, 2011; d´Errico, 2003; Hovers & Belfer-Cohen, 2006; Zilhao *et al.*, 2010). This archaeological tradition uses as evidence for its position the presence of behavioral practices commonly associated with Upper Paleolithic populations in the artifactual record of early modern humans in Africa, as well as non-modern populations in Europe.

It is clear that these different theoretical proposals are not simply variations within a single school of thought. They range across many specific strands of argument using distinct approaches and methods that emanate from different communities of practice. Within this broader intellectual landscape, new sources of relativism continue to flourish, perhaps implicitly and less evident than in the past. This threatens to impede progress towards the emergence of a rigorous discipline of CA with a unified and coherent community of practice.

In this paper we propose a revision to the original anti-relativistic agenda, updating it to address the new epistemological challenges that have emerged over the twenty-year lifespan of CA. Over this lifespan the intellectual landscape has benefited substantially from rich and varied contributions from many disciplines. As we show later, arguments often navigate a specific course through intricate networks of related but qualitatively different theories.

As a fundamental assumption, we shall take for granted familiarity with the original anti-relativistic agenda (Bell, 1987, 1991, 1994a,b; Binford, 1987; Renfrew, 1994). Our focus will be upon selecting points in the context of presenting a novel, comprehensive methodology and space precludes an extensive discussion of the full range of issues associated with subjective interpretations. Moreover, in the meta-epistemological debate, a radical argument against emotionally driven approaches has been championed by proponents of the objectivist movement (Rand, 1964, 1967; Peikoff, 1981). In particular, these authors claimed that emotions arise as by-products of the process of value-formation. In consequence, they cannot be used to assess the validity of those same values. Objectivists reached the conclusion that emotions are irrelevant for establishing whether judgments are true or false. Clearly, if we accept that the only means of validation are individual likes and tastes, then the whole idea of "convincing" people of the validity of one theory over another loses any meaningful foundation. Acceptance of theories would be reduced to, for example, just counting how many people supported a particular theory´s contents. In contrast, we agree with objectivists' view that there is simply no need to surrender to this pessimistic position: reason, indeed, can deliver a reliable method for validating theories and this represents the general goal of epistemological research. Our revision of the anti-relativistic agenda will be grounded, therefore, on the assumption that, contra the post-processualist

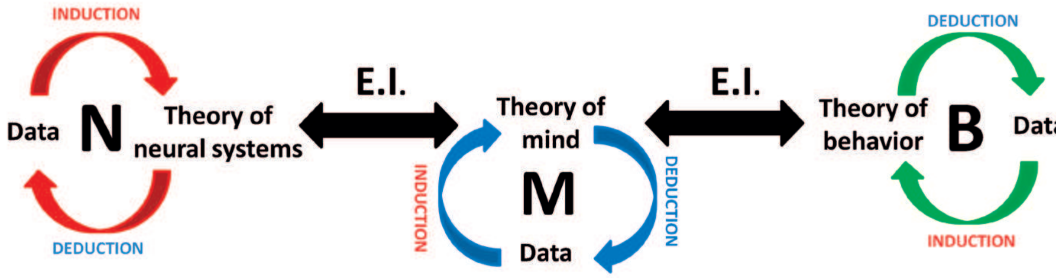

Fig. 1 - Network of inductive, deductive and explanatory inferences (E.I.) among neural, mental and behavioral systems.

school, rational criteria can be provided to validate theories about extinct minds, brains and behaviors. Against this background, we will start by exploring the logical foundations required to establish a methodologically coherent CA. In particular, we will demonstrate the limitations of approaches that aim to provide explanations for the properties of the mind by drawing direct and unidirectional inferences from the archaeological record. Instead, we will discuss the need for CA to embrace a deductive perspective, which can allow networks of theories, constructed and mapped between multidisciplinary domains, to provide explanations of extinct minds´ properties. Since we cannot bring extinct minds into a laboratory, we will suggest that the concept of empirical testability introduced by Bell (1994a) is insufficient. For example, we will later show that symbolic thought cannot be inferred from the simple presence of beads or pigments in the archaeological record. Such evidence needs to be augmented with criteria of plausibility and logical validation to create an efficient strategy for selecting more viable theories from among less viable ones.

With foundational rules for a CA methodology in place, we will then explore the epistemological problems that can potentially confound meaningful comparisons of theories. Case studies will be used to demonstrate the actual existence of these problems in current key debates within CA. Specifically, we will elaborate how our proposed methodological framework provides the conditions and deep structure for what should hold for the proper and meaningful comparison of alternative theories. This framework has to use a theoretical vocabulary of considerable range and precision and this terminology is comprehensively specified in the *Glossary* at the end of the paper.

How to get from artifacts to a theory of mind?

The formulation of a universal method for CA is an ambitious and intricate problem to address. It implies a fundamental premise about the logical operations that need to be adopted to establish coherent connections between extinct brains, minds and artifacts in the record. An approach that aims to account for this problem must necessarily deal with multiple sources of data and types of theory. These need to be mapped one to another in manner that supports justified inferences. Neural, mental and behavioral systems are inter-related entities that exert reciprocal explanatory influences one upon another. Although other system levels, such as social-cultural or bodily systems, are clearly relevant for CA, we will focus on just three levels to illustrate key points in our argument. Figure 1 shows the network of inductive, deductive and explanatory inferences linking interdisciplinary data and theory within and among these three qualitative distinct systems.

So, for example, research in neuroimaging, lesion studies, psychophysiology and neurobiology using extant species enables the induction of theories of neural systems. Similarly, experimental

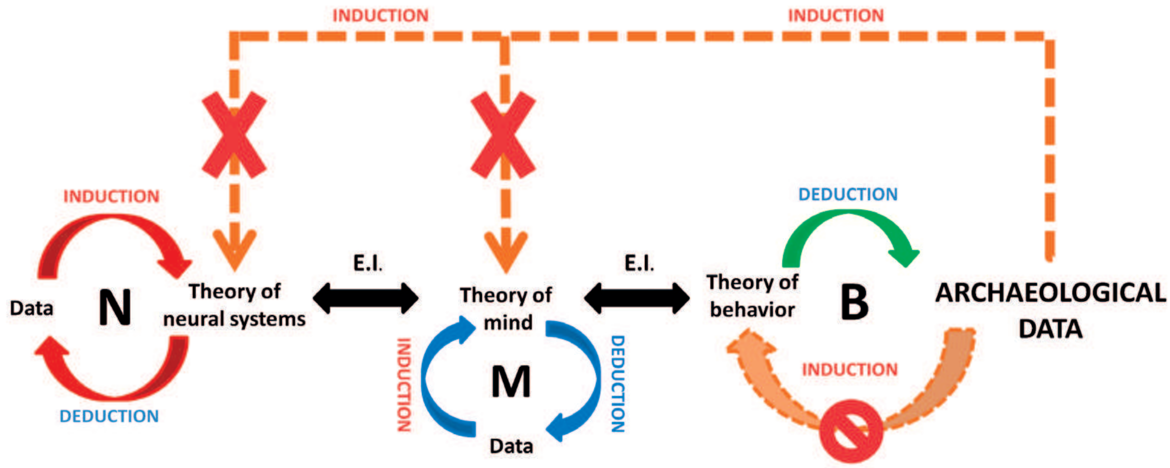

Fig. 2 - Problematic inductive inferences within and between systems. T

research in the field of cognitive psychology and comparative cognition, for instance, can be used to build increasingly more abstract theories of how the mind works, while data from cultural anthropology, ethnography and ethology can do the same with a theory of behavior. At the same time, the suite of theories makes it possible to draw deductive inferences that allow new data to be categorized and explained.

While most researchers would acknowledge that a logical framework of this type is required within CA, the literature itself is replete with examples of inferences that short-circuit the requirements it implies. Some classes of problematic inferences are highlighted schematically in Figure 2. Dashed lines represent inductive inferences that should not be made from archaeological data to minds and brains, while the emboldened arrow highlights inappropriate inductions from archaeological data to behavioral theory. The overall organization here is crucial. Archaeology is limited to the behavioral domain and this prohibits direct inductive inferences. Given that certain forms of inductive inference are problematic within a single behavioral system without making inappropriate assumptions, then the problems compound when seeking to make inductive inferences from one system level to another.

The properties of artifacts in the record can only fully be explained "by means of" a theory of behavior, which is built in the present and *mapped deductively* on the past and can be tested. Handaxes have been argued to fulfill many functions, for example, in butchery (Mitchell, 1995), sexual selection (Kohn & Mithen, 1999), as weapons (Samson, 2006) or merely as by-products of manufacturing flakes (Davidson & Noble, 1993). Handaxes could be described as butchery tools because they have some necessary and sufficient properties that allow us to include them in a theoretical category that defines how a butchery tool ought to be. Inferences about how extinct species behaved with them require theories about the value of particular properties such as sharp edges, the presence or absence of wear, symmetry, the practicability of handling them safely or the contexts in which they were uncovered. Theories provide the necessary scaffolding for inferences and for these examples the properties in focus pertain only to behavior, we have deliberately made no reference to properties of mental or neural systems. This point applies only to inductions within behavioral systems; the problems are more acute in terms of what is required to move among system levels and this problem will be addressed later.

It will be recalled from the previous section that Bell's candidate solution to the problem posed by the post-processualists was to provide a universal method for CA that would indeed enable the validity of claims about prehistoric minds to be directly tested on the artifactual record. It is

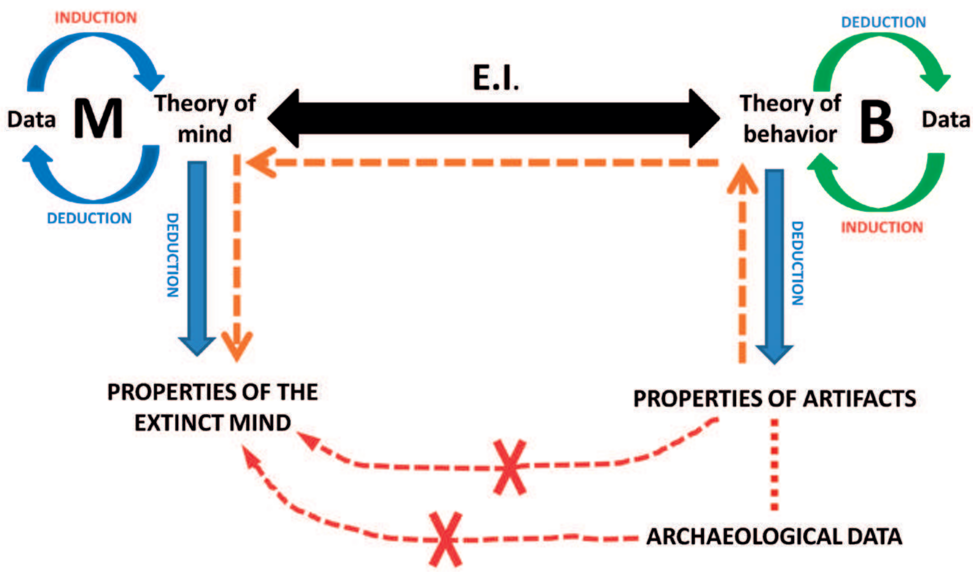

Fig. 3 - Schematic description of the structure and functioning of a methodology for CA proposed in this paper.

clear that Bell thought that he could empirically validate properties of minds from the record. In doing so he conflated theories of behavior with theories of the mind. In the next section we will illustrate this form of conflation in detail for the case of artifacts for measuring weight and inferences about mental constructs. It should be clear, from the connective links in Figure 2, that empirical testability within archaeology is limited to the confirmation of behavioral hypotheses that are deductively constructed from theory of behavior and can be tested in the archaeological record. No empirical proof can be provided to infer directly from artifacts to the properties of the mind. Even if, as Bell implicitly argued, the behavioral system is constructed by a proper deduction from theory of behavior and tested empirically on the artifactual record, properties of behavior are not sufficient alone to explain the properties of the mind connected with it. Even the more solid empirical support of statements in the artifactual record cannot be used to test the characteristics of the extinct minds connected to them.

It is well known that a given pattern of behavior can be open to explanation by alternative theories, and this is obviously true for extinct as well as extant minds. Theory necessarily represents the starting point for testing explanations about the properties of the extinct mind. Some scholars have routinely drawn inferences from isolated parts of the artifactual record to specific characteristics of the mind, adopting a notion of empirical testability, where, for example, the presence of flower pollen in a grave is taken to be indicative not only of ritual behavior but a mind able to process symbols. To overcome these two problems we will introduce a holistic perspective for inductive, deductive and explanatory inference. Networks of inter-related theories of cognition, behavior and neural systems are mapped onto the artifactual record in order to explain properties of extinct minds and brains that cannot be tested through explicit behavioral experimentation.

Figure 3 focuses on mental and behavioral systems to indicate the general structure and functional rules for the method that we are going to propose for CA. This summarizes the arguments we have already introduced while also anticipating the content of what follows. In contrast to Figures 1 and 2, this new diagram highlights three features. First, it makes prominent the role of deduction from theories to properties of minds and of artifacts. Second, within this bigger picture it is important to note that a key role is preserved for induction and deduction within research on mental and behavioral systems. Third, it shows there is no direct connection between archaeological data or properties of artifacts to properties of extinct minds. Rather, the connection is mediated indirectly from properties of artifacts via theories of behavior through theories of minds to specific properties of minds.

This schema alone does not cleanly resolve the problem of providing objective criteria for empirical validation of theories – there is no escape from the problem of not being able to directly test explanations of mental systems that no longer exist. However, a proposal for non-empirical validation of theories will be advanced that arguably provides a rigorous framework for selection that is sufficient to overcome relativism.

Problem of testability

In the second chapter of the seminal book "The Ancient Mind", James A. Bell (1994a) argued that archaeologists should aim to construct testable theories of prehistoric cognition as opposed to interpretations. According to his view, theories must be constituted by statements emerging directly from observation of the artifactual record and that, in turn, can be empirically tested on it. At the same time, other statements might be derived, which are not directly connected to the artifactual record, but can be subject to empirical refutation by virtue of logical connections with assertions that can be conversely tested on the archaeological evidence.

To help understand this logic, Bell revised the famous Renfrew´s (1982) example of the stone-based system of weights from the four thousand year old site of Mohenjo-Daro, in the Indus valley. By finding evidence of the existence of cubic stones, whose weights are multiples of the same unit, Renfrew advanced a theory of the cognitive processing of weight systems in this civilization. A relevant part of his argument can be structured in the following way *(where <-> = implies)*:

a) *discovery of calibrated stones <-> concept of weight + existence of units*
b) *existence of units <-> existence of modular measure*
c) *hierarchy of units <-> existence of a system of numeration*

In other words, the discovery of calibrated stones suggests both the existence of a concept of weight and of constituent units (a), which are necessary to support the idea of modular measure, (b). Moreover, the existence of a system of numeration, organized in numerical categories, follows from the assessment of the hierarchical relationship among units. Therefore, the assertion of calibration is directly testable on the artifactual record, by seeking for similar stones that hold no weight relations and can therefore invalidate the inference in (a). Conversely, the assertions (b) and (c), are not refutable from a direct observation of the archaeological evidence (to this goal there ought to be written material from this society that documents the use of system of numeration, for instance), but they can be in any case rejected by considering their logical connection to (a), which is both testable and necessary to support the validity of (b) and (c).

This indirect approach to testability is formalized by adopting the concept of *entailment*, which Bell (1994a, p. 19) refers to with the expression:

> *"if X entails Y, then a mistake in Y indicates that there is a mistake in X".*

Therefore, in order to produce an entirely testable theory, statements not directly testable themselves must entail statements which are directly testable, so that the absence of clear evidence of a system of units in Renfrew´s example necessarily would lead to the invalidation of any potential conclusion concerning the existence of numerical systems. Indeed, the logic of entailment implies the obvious rationale that there is no concept of weight without the identification of artifacts that can fulfill the role of units, as well as no system of numeration.

In the previous section, we discussed the difficulties associated with empirical testing and inference (Figs. 2, 3). In the case of Renfrew´s example of the Mohenjo-Daro weight system, the argument is constructed through a proper deduction from theory of behavior, which enables us to understand how a system of weights should be universally constituted. However, the fundamental problem here lies in the deceptive conviction that statements about prehistoric cognition are being tested, whilst actually testing assumptions applying within the behavioral system. As seems to be the case with much of the first wave of CA (see Renfrew, 1994; Preucel, 2007), both Renfrew and Bell focused on relationships that connect several components of a behavioral pattern, namely the stones and their potentially calibrated weights, in order to categorize the use of units of measure in a system of numeration. Classifying the use of calibrated stones with the label "system of weight" tells us little about the nature of the mental processes required to use it and the concept of weight that stems from this analysis can be different from the one we currently hold. Indeed, when referring to the single behavioral system, testability is warranted by direct inference from the archaeological record or, as illustrated above, through the logic of entailment. It is not by chance that Bell more than once used the expression "indirect way for **empirical** refutation of statements" (our emphasis). On the other hand, when mental *processes* are considered, the shift from a behavioral system to a mental one cannot be informed by empirical analysis alone, either directly or by entailment. For example, it is possible to characterize the behavioral practices in different hominid species with complex logical maps (Haidle, 2009, 2010, 2012; Lombard & Haidle 2012). However, here the behaviorist fallacy holds. You cannot infer the identity of underlying cognitive processes from observation of the behavior alone, even with an abstract schema of the sort used in our illustration of a system of numeration. Therefore, specific behavioral practices, considered in isolation from the rest of the behavioral architecture that characterizes one species/population, might be sustained by a different pattern of cognitive operations and ultimately associated with different mental capabilities.

This general point was originally discussed in the context of Wynn´s seminal review of cognitive evolution (2002). In his comments on that review, Deregowski argued that rotation of tridimensional figures and estimation of symmetry were not necessary to produce Early Acheulean handaxes. An alternative, but easier strategy can give the same result. In this case, a simple mechanism of perceptual priming would automatically have led to choosing the correct shape when presented with two possible alternatives. The hard epistemological challenge for CA is to put the flesh on the mere bones provided in Figure 3 to answer the question "how is it possible to test assertions about the evolution of the human mind from the archaeological record?" In framing an answer to this question, it is necessary to deal with the post-processualist counterarguments to Bell's agenda.

Given what has been argued so far, CA must chart a new and clear epistemology to avoid the black and white choice of two wholly unproductive options. One option remains Lewis Bindford's (1987) materialism, according to which drawing psychological inferences from material facts, via "paleopsychology" (Binford, 1965), is of dubious value. The other option is relativism, where anything goes, according to the authors´ interpretations, likes and so forth. In the next section we will explore a new epistemology offering some precise conceptual scaffolding for the "logical", rather than empirical, validation of explanations.

The deductive approach

Structure of the deductive method

Our proposal to develop a new epistemology focuses on use of a deductive framework to explain the archaeological record. This deductive method aims to map a suite of theories that account for systems of interest and how they behave. Behavioral, mental and neural systems are causally inter-related, each with their own qualitatively distinct architectural properties, and exert reciprocal constraints one upon

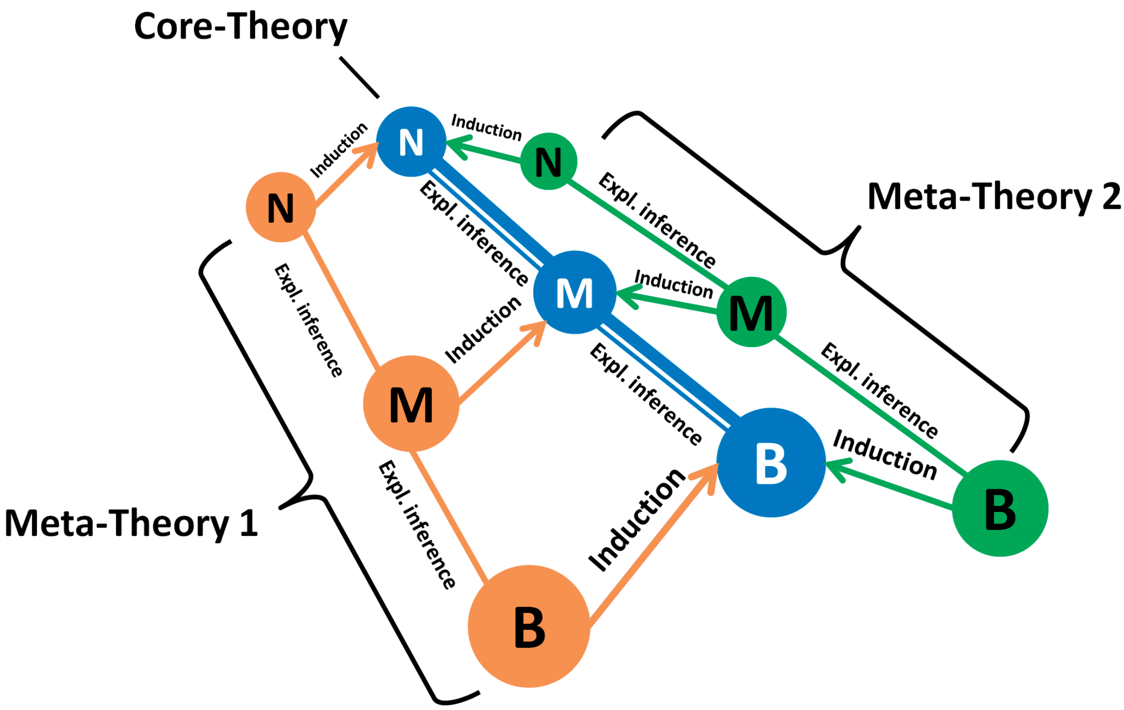

Fig. 4 - Three-dimensional representation of the first stage of our deductive method proposed for CA. The spheres represent the three assembled systems (N=neural, M=mental, B= behavioral), mapped horizontally through explanatory inference, in order to form meta-theories of system-interaction.

another. As we explain later, in order to better understand these reciprocal influences, we need a well defined set of macro-and micro-theories of how each type of system works (Barnard *et al.*, 2000). The notions of macro and micro-theory are deeply rooted in a hierarchical conception of how assembled systems are constituted and serve to explain how entities that are part of each system behave (Newell, 2000). A macro-theory can be roughly defined, in fact, as a theory that explains how the subcomponents of an assembled system interact, while each of these subcomponents requires in turn a micro-theory to explain the properties of its constituent parts.

The challenge is further complicated by the fact that our focus in CA is on understanding the neural, mental, and behavioral systems of not just one species of hominoids, but many. Because multiple macro- and micro-theories of qualitatively different systems and many species are required, we clearly need a way of thinking about all these inter-relationships in a systematic rather than piecemeal way. To realize our method, we have to organize the deductive framework and specify the first major premise that can lead to general principles of interaction that govern the behavior of any system. Figure 4 illustrates this by referencing two new constructs: Meta-theories that relate system levels for a given species (e.g. *Homo sapiens sapiens* and *Pan paniscus*), and the concept of Core-Theory which aims to capture what governs interactions among system levels for all species across any and all system states. The later construct and its detailed properties will be incrementally built up as our argument develops. For the present, it is sufficient to note what Figure 4 highlights is that Core-Theory must be induced from Meta-Theories. In this paper, Figure 1 diagrammatically introduces the function of an explanatory inference and its more precise definition can now be stated. "Explanatory inference" is the logical operation adopted to construct a particular Meta-Theory and it refers to the bidirectional explanatory power these

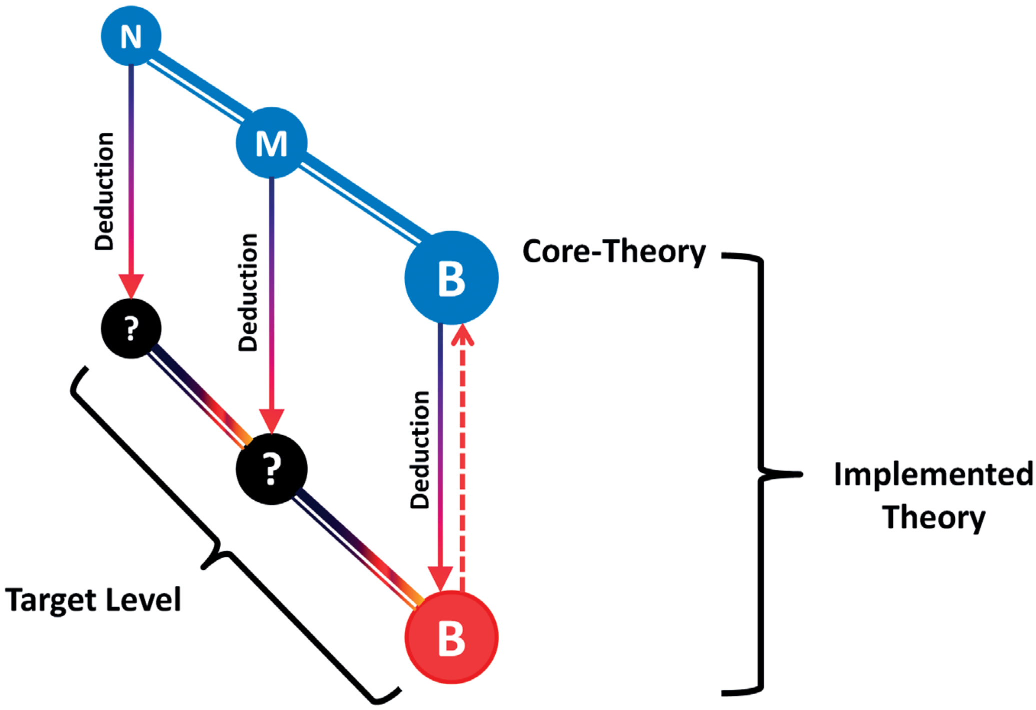

Fig. 5 - Vertical mapping from the core-level allows to complete the missing fields (interrogative marks) in the target level, in relation to the structure of the behavioral architecture in the target level.

systems reciprocally hold. This procedure of horizontal mapping is repeated for different species/populations and many meta-theories are produced until all of these are aggregated in a synthetic "core-theory".

The value of core-theory is that it should enable us to predict through explanatory inference, for instance, how the variation in the architecture of a mental system (M) affects a behavioral system (B), by virtue of the principles that universally bridge and constrain the various systems. However, a core-theory appears as a pure abstraction and should be considered as a way to account for the comparisons of meta-theories and the extraction of invariant rules of system behavior.

The next step for CA is to recruit the power of deduction to perform a vertical mapping from the level of a core-theory to a target level of interest (Fig. 5). In CA, only one system is available within the target level - the behavioral architecture found in the artifactual record, albeit where the evidence of the complete system is necessarily partial. The obvious point is that deduction is required to infer properties of the missing target mental and neural systems. This method, as depicted in the figure, can be represented with the following expression in formal logic:

If X<->Y<->Z
and X = X*
then X*<->Y*<->Z*

In line with the structure of deductive arguments in logic, the validity of the conclusion follows directly from true premises and for every given X it would be possible to find a specific Y and Z, by virtue of the universal rules that are implicitly stated in the major premise.

Figure 5 is a refinement of our earlier Figure 3 that now makes clear the role of explanatory inference. If a direct horizontal mapping is impossible from the target behavioral architecture to the other systems in the same level, the only way to fill the gaps of knowledge results in vertically inferring them by virtue of the universal principles of connection that bind elements in the accessible

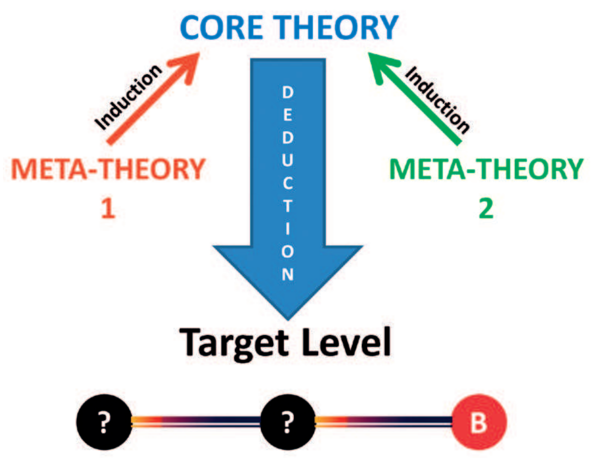

Fig. 6 - Two-dimensional representation of the proposed methodology (implemented theory).

meta-theories and are synthesized by the core-theory. In other words, the diagram, as formulated, tells us that having different perspectives on how neurons, cognitive systems and hominoids behave, warrants sufficient generality to infer from them how a given behavioral architecture, detected in the artifactual record and linked to a target species/population, is associated with a mental and a neural architecture. "Implemented theory" is the way we define the result of the vertical mapping between the core-theory and the behavioral architecture in the target level. In other words, an implemented theory is the final body of theories that is provided in CA to explain properties of extinct minds and brains. A schematic synthesis of the whole logical process that defines our proposed methodology is shown in Figure 6.

This deductive method obviously relies on two assumptions. First, relationships between system levels are subject to deep abstract principles (a), which exist independently from the specific theories adopted to explain them. This means that variations in the properties of a system necessarily produce changes in related properties of connected systems. For example, capacity is a property of both the neural and the mental system that accounts for the amount of information a neural network, as well as a cognitive architecture, can potentially handle (Halford *et al.*, 2007). According to (a), increasing the capacity of the neural system, for instance by altering the architecture of constituent networks, increases also the capacity of the cognitive one. Therefore, the behavioral repertoire that can be potentially handled by these enhanced systems is also "increased". At the same time, our second assumption (b) implies that those principles applied in the same way in the ancient past as in the present. It is well known, as Hume (1739) argued, regularities in the present will not necessarily apply in the future, but we believe we can trust that biological principles past and present are congruent simply by virtue of the evolutionary relations that link organisms. Our proposed methodology shares with Bell's original conception the property of assuming indirect strategies as a tool to validate theories. The main difference between our approaches, however, lies in the fact that we do not recognize the logic of entailment as sufficient to check the validity of statements between two different aggregated systems.

As an illustration of the difference between using our holistic and deductive approach as opposed to that relying on entailment, we can consider Acheulean tools. These are created by the staged removal of flakes from a core to create a bifacial and symmetrical entity. Wynn (2002) argued that mental rotation of three-dimensional figures played a key role in the process of manufacturing these tools. However, nothing in the record alone can directly be used to argue against the involvement of mental rotation without a theoretical context to support an appropriate deduction. In contrast, implications can be invalidated in cases such as Renfrew´s example, when stones with non-standardized weights are found. The point is that inferences from evidence across different domains, when isolated from a theoretical context, can lead to the formulation of distorted conclusions. In fact, statement X "there are symmetric relationships between parts of this artifact" entails statement Y "symmetry is produced by tri-dimensional rotation of figures in working memory", but there is no empirical evidence that can disprove this entailment in the artifactual record, because the mind does not fossilize.

Problems like these need to be solved only by checking if the whole behavioral architecture of the population that produced those artifacts is compatible with a hypothesized mental architecture. This needs to be derived via a deduction from the core-theory that is built upon the firmer foundation of empirically warranted meta-level theories. We need to go beyond the idea of testing single statements and the adoption of linear chains of inferences characteristic of Bell´s falsificationist agenda. Instead, we need to shift to an alternative conception of "testability", more similar to a form of holistic evaluation of theories (Godfrey-Smith, 2003, p. 31). To reconstruct missing mental and neural systems we need to examine not single statements that are entailed, but entire meta-theories. For a given target behavioral architecture, a core-theory of system behavior would predict properties of mental and neural architectures (i.e.: the core-theory that explains the connection among systems in modern humans and apes entails the conclusions about the mental architectures of other extinct hominoids).

In framing our approach so far we have concentrated on only three systems. This should not be taken to exclude contributions from macro-theories of other relevant but qualitatively distinct systems. Clearly, properties of the biomechanical and sensory systems of a particular body morphology also constrain relationships to cognitive and neural systems. Such constraints may be informed by models of embodied cognition (Lakoff & Johnson, 1999; Clark, 2008) and their application to the study of material culture (Malafouris, 2008a,b,c, 2010a,b; Mithen & Parsons, 2008). The same applies for constraints that propagate from higher order social systems. An account of demographic changes would give more power to deductive mapping, both in the horizontal and vertical component. One example of this could be the hypothesized link between group size and rates of cultural innovation, which comes with at least some authority from mathematical modeling (Shennan, 2001; Powell *et al.*, 2009). Furthermore, recent empirical analyses have proved the existence of a correlation between technological complexity and population size. In particular, Kline & Boyd (2010) meta-analyzed a set of ethnographic data on artifacts and behavioral practices of populations living in different Oceania islands and concluded that islands with small populations had a simpler marine foraging technology (but see Read, 2012 for a counterargument). More widely, an extension of the three-systems logic would offer additional constraints and allow a more informative mapping to the archaeological evidence (i.e.: both theories of the body and demography are informed by paleoanthropology).

In a similar vein, constraints on neural architecture can come from paleoneurological studies on endocasts and neontological enquiries characterizing relationships between variation of brain size, shape and functions in human and non-human primates. The paleoneurologist Emiliano Bruner, for instance, has demonstrated that modern humans, but not highly encephalized Neanderthals, are characterized by a non-allometric expansion of the upper parietal regions of the endocast (Bruner, 2003, 2004, 2008, 2010, 2011), an autapomorphic trait that is supported by a specific ontogenetic phase in modern humans that has no counterpart in species that predate anatomically modern humans (Gunz *et al.*, 2010; Neubauer *et al.*, 2010). This morphological variation, which determines the characteristic globular form of the modern human brain (Lieberman *et al.*, 2002), contrasts with the elongated structures of more archaic populations. This difference has been associated with potential disproportional white matter expansion and enhancement of parieto-frontal connectivity (Bruner, 2003, 2004; Coolidge & Wynn, 2008). This enhanced connectivity, in turn, could be a candidate biological substrate for selective cognitive advantages (Jung & Haier, 2007) in modern humans. This hypothesis has been recently tested in neontological studies on modern humans. A slight correlation between brain globularity and information processing speed has been demonstrated (Bruner *et al.*, 2011). Additionally, these researchers claimed that this effect might have been more pronounced on an evolutionary time-scale. This form of analysis well illustrates how empirically supported constraints relating system levels can contribute to the substance of core-theory.

One key question remains to be addressed. Under circumstances where there is no direct empirical evidence to refute theory, and a number of implemented theories are available, how do we select the candidate that best accounts for the context of the record?

Problem of validation: criteria for selection

Any deductive argument can lead to false conclusions if the premises are false (Godfrey-Smith, 2003, p. 41). Use of our methodology involves a series of stages (Figs. 5, 6) and false conclusions could arise as a result of the adoption of flawed macro-theories, by performing erroneous horizontal mapping between systems, or by creating a corrupted core-theory. Even an adequate core-theory would allow errors to propagate into the vertical mapping, if its minor premise is wrong, as for instance in case where there is some problematic interpretation of the artifactual record, and hence flawed behavioral architectures. In this respect, our proposed methodology allows us to pinpoint with some clarity where intricate arguments can be flawed. This same property also means that we are going to need two different stages to decide among candidate implemented theories. These two stages once again correspond to the two main phases of mapping.

The first stage basically involves the construction of a core-theory. Here, evaluation simply means that principles must be supported by empirical data. Experimental work would serve to define macro-theories of the assembled systems of interest, by virtue of the study of their micro-theoretical components, and to understand the way they constrain each other. This validation stage is the "easier" part of the epistemological problem of CA. This should not be taken to mean that the *construction* of a core-theory is an easy task, but that in this phase there is still a connection to hard data. Extracting principles of interaction between levels of architecture for extant species is far from an easy task. There is not much agreement about how minds should be represented in whole or in part. Even though there are candidate unified theories of cognition (e.g. Newell, 1990) and macro-theories of mind (e.g. see Barnard *et al.,* 2000), there are vast numbers of micro-theories to account for specific phenomena and not much in the way of consensus about how best to decompose minds or about how individual micro-theories can be reconciled as parts of a bigger picture. However adequate the micro-theories might be within a discipline, a key challenge for cognitive neuroscience, cognitive anthropology and comparative psychology would be to develop convincing rules to connect their own system-level concerns with those at an adjoining level - a task that becomes even harder as the number of constraints to be accommodated increases.

A crucial but also hard aspect of the validation process lies with the vertical mapping from core-theory to the target level "missing" system, be it mental or neural. As argued earlier, evidence cannot play a part here. The "logical validation" that is performed within our methodological schema requires criteria. Some criteria for selection can be borrowed from David Chalmers´ (1995, 1996) analysis of the "hard problem of consciousness" (for a review see Searle, 1997, 2004). This problem shares with CA the fundamental epistemological issue of inaccessibility of the object of science to scientific methods. The subjectivity of first person experience can no more be investigated with scientific methods, than can the minds of extinct hominoids. Chalmers´ solution involves a series of non-empirical principles to evaluate candidate theories of non-observable phenomena. The six criteria proposed by Chalmers are adapted below for CA:

a) **Internal Coherence**: when mapped from a core-theory to the target level, the principles that bind architectures must be preserved in the target level. In other words, the rules adopted to infer properties of the missing systems should be coherent with those predicted by the core-theory. Not complying with this criterion would imply an incoherent vertical mapping and the whole deductive process would be corrupted.

b) **Simplicity:** Theoretical schema should aim for simplicity in any of their component parts. In particular, the result of vertical mapping should be a simple target level meta-theory. However, it is worth noting that simplicity is not always possible, due to the fact that there are no guarantees that the world is simple (Godfrey-Smith, 2003, p. 55). It should be possible to validate complex theories as well, if the payoff exceeds the increase of complexity.
c) **Homogeneity**: Theories must show no gaps in aspects of reality that they intend to cover.
d) **Inclusivity**: Theories should not deliberately exclude aspects that cannot be accommodated within their logical structure.
e) **Consistency:** There should be no contradictory parts in a single implemented theory. A statement and its negation cannot be demonstrated within the same theoretical schema.

David Chalmers, in his book "The Conscious Mind" (1996 - Chapter 6), supports the idea that the six criteria for selection exert constraints on the *plausibility* of theories and that this can act as the gold standard for assay in non-empirical situations. However, Chalmers does not provide any precise definition for this concept. He prefers to use an example to discuss the idea that two alternative theories might be both perfectly rational in terms of the logical connections between elements, but they can hold a different level of plausibility. In this way, he imagines the situation of two competing hypotheses. According to the first one, the world has been created fifty years ago, together with all fossils and memories, while in the second hypothesis evolution really happened as we know it. Comparing these hypotheses, one must conclude that both are rationally conceivable, but the first one is implausible, because it is too complicated and based on a series of unnecessary assumptions.

To solve this series of issues, we propose a definition of plausibility that takes into account the number of *ad hoc* hypotheses that are produced to connect the core and the target level during the construction of an implemented theory. *Ad hoc* hypotheses, in fact, could be used to resolve issues with each of the principles derived from Chalmers (1996) and listed above. They can be employed to correct problems of coherence in the rules adopted to map the various elements within the whole theoretical schema (crit. a), to cover gaps of knowledge left behind or to deliberately rule out uncomfortable parts (crit. c-d). They may also be used to justify contradictory aspects of the theory by creating "exceptions" (e), while simplicity (b) results as deeply influenced by the number of changes that are produced to align with the other criteria. It follows that implemented theories that need to be adjusted in any of these ways are less plausible than those able to perform a coherent mapping without recourse to logical alterations. Therefore, this variant of plausibility works by embracing Occam´s razor. Selection among alternatives is now dictated within an eliminative perspective (Platt, 1964), that rules out all the more implausible alternatives *en route* to adopt a preferred theoretical schema. To help understand this generic logic, we can draw on Walton's (2001) discussion of the case of a juridical diatribe in Ancient Greece. Two contenders, a big man and a little one, were involved in a fight without witnesses. Each of the contenders had to convince the jury that the other had started the fight. It would be implausible for the jury to think that the small man assaulted the bigger man first, without posing some *ad hoc* hypothesis to justify this inference. For instance, claiming that the little man is an expert martial artist would raise the level of plausibility of the hypothesis that he actually started the fight. Martial experience would compensate for lack of size. However, if it were not possible to empirically check the fact the little man was an expert fighter, then there would be no grounds to suppose that this hypothesis is actually more plausible than the first one and there would be therefore no reason to prefer it.

In CA, reference to evidence is typically more indirect and elusive, so that even the most plausible implemented theory would quite likely retain a speculative component in the vertical mapping phase of the framework. But as we have argued, this does not result in epistemic relativism or equivalence in the value of the conclusions: *selection for plausibility* is grounded in explicit criteria for theory validation, where Bell´s empirical testability perspective is not applicable.

Comparing alternative theories

Problem of Incommensurability

To evaluate the content of alternative implemented theories, it is necessary that the same basic principles are applied while developing those theories, from micro-theories to the full implementation. Theories of complex systems are seldom simple and cannot be easily reduced to unitary elements that can be easily manipulated. As we shall see, a network of theories at different levels may be organized into hierarchical layers and, when one is mapped to the others, relationships within and among their constituent layers must be treated in a disciplined way (Barnard *et al.*, 2000).

If everyone were to use a different set of rules for mapping among system levels, then the final cognitive archaeological theories that are implemented and compared would be incommensurable. The word "incommensurable" implies that the logical structures involved in the construction of their premises and in making deductions differ. Consequently, it would be impossible to properly compare those implemented theories. Incommensurability can be responsible for confusion and relativism, because some theories that are presented as real alternatives to other ones are alternatives not because they are theoretically advantageous, but because they have been assembled with an improper methodology. At the end of the paper we shall illustrate these problems of comparison with two case studies of inferences from the presence of beads found in Neanderthal and Early Modern settlements.

Problems of incommensurability can be further refined into three categories:

1) *General Incommensurability*: Meta-theories (see Fig. 4) are assembled with rules that are not universal, but specific to the theory being implemented. (i.e.: some parts of one system architecture are mapped onto different parts of other architectures, or parts are omitted, etc...). Here the mappings are incoherent because their premises are problematic.
2) *Incommensurability within architectures*: assembled systems are mapped correctly, following a universal logic, but the rules of construction within each mapped system are different, so that the system architectures themselves are incongruent. Incongruence, in this case, is the cause of incoherent mappings.
3) *Incommensurability between architectures:* assembled systems are constructed according to the same rules, but the different layers that constitute each architecture (Fig. 7) are again incoherently mapped to the layers in another architecture using a set of different rules. (Same system structures, different logic to connect them).

In order to attempt to find a solution to these three problems of incommensurability, we will refer to the model proposed by Philip Barnard and colleagues (2000) for mapping theories, revising it on the light of our methodological framework and suggesting its use as a potential uniform method in CA.

Barnard´s model: rules and problems

Barnard *et al.*'s framework was originally derived from research on human use of modern rather than ancient technological systems and therefore the problems it addressed parallel those of CA (see Barnard *et al.*, 2000 and reference therein). A key objective of their work was to create a method to bridge systemic architectures of a qualitatively different nature (e.g. mental & technological systems) in a coherent way that would support an understanding of the conjoint behaviors of human and technological interactors.

The basic logic of their approach is based on hierarchical decomposition (Fig. 7). Every architecture is an assembled system [A], composed of a series of basic interactors [B]s. At the same time,

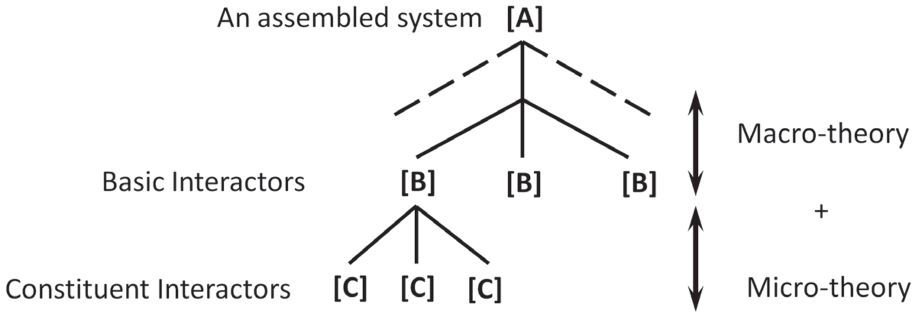

Fig. 7 - **Hierarchical decomposition of an assembled system into two layers.** ***Reproduced with permission from Barnard (2010b), in Nowell & Davidson: Stone tool and the Evolution of Human Cognition. University Press of Colorado.***

each of these basic interactors is itself composed of constituent interactors [C]s. A macro-theory of an assembled system is required to explain how the basic units interact as parts of the overall system, while micro-theories are required to explain how the constituents of each basic interactor govern its behavior. So, each interactor is a behavioral entity that occupies a specific position within the hierarchy of an assembled system and is so named because it interacts with other elements within the same layer.

The behavior of any interactor is determined by two main considerations that act concurrently on it: (1) the nature of that interactor´s constituents, and (2) the constraints that are exerted on it by the other interactors present at the same level within the hierarchy. So, for example, according to Barnard (2010b), a behavioral system assembled to make stone tools might be composed of a human agent [B1], a hammer [B2] and a core [B3]. A tool using system might have the same human agent [B1] but now replace the core and the hammer with the tool [B4] and an animal carcass [B5]. Likewise, an hypothesized mental architecture of a Neanderthal might be decomposed into a particular set of mental subsystems (Bs) and that of a modern human into a different assembly of Bs, with some of these in common between the two architectures and others distinct. Similarly, their brains would be composed of neural circuitry with shared cellular electrochemistry but different network architectures whose differences really can be mapped onto hypothesized differences in mental architecture. Figure 8 now illustrates a schema for mapping networks of neural, mental and behavioral theories.

Assembled systems can be mapped horizontally by adopting the following basic principles:

1) An assembled system [A] in one layer (e.g.: here neural or mental) enables its collective capabilities to behave as a basic unit within a system assembled at some superordinate level, here mental or behavioral (A→B), where its properties now constrain the behavior of the new superordinate assembly.
2) The behavior of a basic unit [B], when incorporated into a superordinate system, must also carry with implications from a relevant body of micro-theory from the lower layer (B→C), since these also constrain how the relevant B may behave within the superordinate system. For example, for system assembled with an expert stone knapper [B] or an inexpert one [B'], the two may share a common macro-theory of how their minds are composed overall, but require different micro-theories of their perceptual, manual and planning skills.
3) The relationships are bidirectional, in the sense that the [B]s in a superordinate system can constrain an [A] in the subordinate one (B→A) too (but see below for an alternative conception of the principle of directionality). To continue with the same example, the particular micro-theory needed for an expert stone knapper would have arisen only if that individual had a history

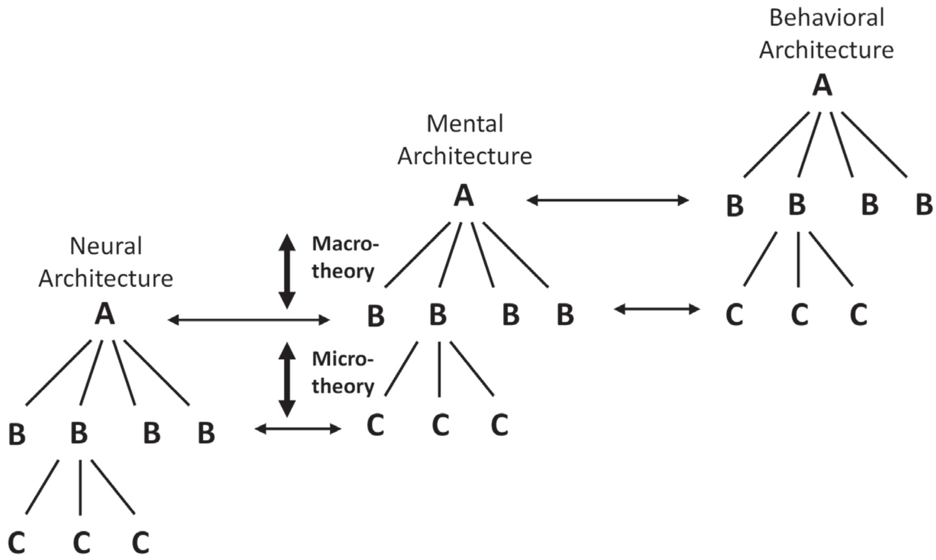

Fig. 8 - Barnard´s diagram for horizontal mapping of the three architectures in cognitive archaeology. Reproduced with permission from Barnard (2010b), in Nowell & Davidson:* Stone tool and the Evolution of Human Cognition. *University Press of Colorado.

of training and practice in similar behavioral architectures in the past.

Taken together, it should be clear that properties and behavior of interactors present in mental and behavioral systems are a product of families of constraints and that these tightly connected systems reciprocally influence each other. This idea of bidirectional influence can be contrasted with a more neurocentric perspective, where causal relationships between systems are frequently cast as unidirectional and commonly oriented from the neural to the mental right through to evidence in behavioral systems. For example, Klein (1995, 2000, 2001, 2008) explained what he considered to be the abrupt emergence of Upper Paleolithic innovations by reference to a punctiform mutation in modern human brain architecture, incurring at ca 60 kya. In his view, this neural enhancement promoted modern human cognitive capabilities and in particular the extraordinary ability of our species to innovate.

While Barnard's framework has much to commend it, there are only a few examples of its application to practical cases in modern and ancient technological systems. It is clear in broad terms from Barnard's description that the things that interact in neural architecture relate to circuits, cells and their electrochemistry, those that interact in mental architecture concern states of, and operations on, "information", while those in behavioral architecture relate to changes of state in animate and inanimate entities in our physical and social worlds. However, for each of these systems there is a great deal of ambiguity about what really constitutes a specific interactor and which level it should be assigned to in a hierarchy. This problem is particularly acute when it comes to mental architecture. In the field of cognitive psychology as a whole, there is little agreement on how we might best define the components (i.e.: [B]s) of the mind. Even worse, there is a vast numbers of candidate micro-theories applied to specific domains of mental life among which it is hard to choose on the basis of evidence currently available and little in the way of a body of macro-theory to organize them. We have a problem in determining what the [B]s and [C]s are and what layers to assign them to when we apply this approach to CA.

If the aim of the diagram is to provide a tool that is universally valid, independently of the macro-theories we choose to adopt, and the implemented theories produced with this model should be commensurable and accessible to the criteria for selection we proposed earlier, then it is necessary to generate a list of rules of functioning. These rules should be followed universally by all implemented theoretical proposals. If this fundamental condition is not met, the model once again risks allowing relativism. In this case allowing anything to be an A, a B or a C enables a theorist to propose connections that reinforce their specific theory and make it difficult to compare that theory with others.

By way of clarification, though necessary as a starting point, Barnard's descriptions of the interactors in neural, mental and behavioral systems leave us with a problem of ambiguity to resolve. The main problem with the absence of precise rules for construction of architectures is that they might be built by adopting different strategies. As a consequence, arbitrary rules of construction can lead to architectures that are incongruent when mapped. It appears from Figure 8 that while mental architecture is defined as the entire structure of one species´ mind, constituted by a set of units that interact, which in turn can be decomposed in constituents, the neural architecture does not seem to account for the entire brain, but only for one extensive part of the whole circuitry. The behavioral architecture, as well, is focused on just one behavioral practice and the entities it involves. It does not seem to address the entire spectrum of practices accounted for by the mind of a particular hominine and the wider culture within it is embedded.

This problem with the original formulation has been recognized by Barnard (personal communication) and relates to the "*Problem of optional incompleteness*". Complex biological systems, which involve huge networks of interactions, can hardly be depicted by synthetic diagrams. This can be seen in neural architecture, for instance, for which a complete description of the whole set of interactors that constitute it would require considering almost limitless amounts of entities and processes (e.g. 10^{11} neurons plus many neurotransmitters, hormones and the endocrine system). The same applies to behavioral systems. Over the course of a human lifetime and over all the tasks accomplished by people in different human occupations and roles, there are equally vast numbers of possible behavioral systems. Following these assumptions, it appears that all layered architectures cannot be completely inclusive. However, Barnard notes (personal communication again) that his focal point for theory development is a macro-theory of mind that is fully specified, while his strategy is to leave adjacent layers only partially specified in a manner that most efficiently informs the development and testing of his theory.

In our view, for the purposes of developing this framework for CA, the problem of "optional incompleteness" must be taken into account by embracing a "realist" agenda that would allow us to recognize the limits of incompleteness. We should not confuse "optionality" with "anarchy". This means that the optional choices in decomposing and configuring architectures must be made *a priori*. They need to be considered in the stage of epistemological discussion and not *a posteriori*, just before the application of a particular implemented theory. In other words, the fact that architectures cannot be completely inclusive by nature cannot be used as a justification to allow any potential manipulation of their structure and hierarchical organization.

Assembled systems need to be as congruent as possible, starting from the nature of the [A]s, which must be set at a comparable level of reference/complexity. Even though we might say that a chosen mental architecture is incomplete, this should not allow us to arbitrarily change the level of reference in the other architectures by replacing the brain with a part of it and then mapping the partial neural architecture on the whole mental one. So, if the [A] in the mental architecture is intended to represent the overall structure of the mind, then obviously we would perform an incoherent mapping if we chose some substructure such as the arcuate fasciculus´ circuitry to support this role in underlying neural architecture.

Now, examination of Barnard's diagram reveals a conceptual difference in the composition of mental and neural architectures on the one hand and behavioral ones on the other, that indicate we need to add to his schema to achieve full coherence of horizontal mapping. Also, this addition will help counteract inappropriate inferences from behavioral systems to mental ones.

With neural and mental architecture, the set of basic units that form the assembly are invariant – all "standard" humans have the same number of mental subsystems/processes and the same sets of basic neural circuits – although there will, of course, be naturally occurring exceptions. Variation in capability of the system, such as expertise at manual skill, vocal communication or problem solving, occurs in the level captured by micro-theory. The same clearly does not apply with behavioral architectures. Across, for example, Mousterian tool making, hunting, ornamental marking, food gathering and preparation, procreation, caring for the young and old, migrating, or conducting simple burial, there is significant variation in the Bs that enter into the systems and accordingly variation in both layers of the hierarchy for behavioral systems.

As expanded upon later, two interconnected points follow from this observation for how we should frame use of horizontal mappings. First, when making horizontal connections from mental to behavioral architecture, the selection of what is connected must be made in a manner that is not generic, but sensitive to the target context. Prior to the invention of writing, stories that could not be depicted had to be memorized and vocally transmitted and learned. Second, there is the inverse problem that when attempting to make horizontal connections the other way – from evidence in a behavioral system to mental architecture - a formulation such as Figure 8 may be used to justify erroneous generic inferences. For example, existence of a basic interactor in a single behavioral system involving a target species, such as bead ornamentations, has been used to argue for the generic presence of symbolic mental capabilities (Zilhao *et al.,* 2010; d´Errico *et al.*, 2005; d´Errico & Stirner, 2011). However, the wider context of other behavioral systems for that species may contain evidence that the presence of bead ornamentations is open to explanation by non-symbolic mental capabilities.

Barnard´s model extended

It is worth exploring in a little more detail the kinds of mapping from mental architecture to a behavioral architecture that can lead to distorted conclusions. Improperly constructing an architecture using a single example or class of behavior, such as ornamentation, rather than a larger "repertoire" of behaviors, represents a variant of the second type of incommensurability, that within architectures. In this case, the same macro-theory of mental architecture can be mapped onto different forms of behavioral architecture, resulting in markedly different implemented theories.

An example of this class of improper reasoning can be illustrated in a thought experiment adapted from work by Wynn (2002). It relates to why incompleteness cannot justify changing constituent rules for architectures. Suppose we were to start producing Acheulean artifacts as a hobby tomorrow. Having made some, we put them in a secure case where they are found by a cognitive archaeologist in the future. This archeologist could proceed to structure a target level where the mental architecture accounts for the entire structure of our mind, while the behavioral architecture represents the behavioral pattern underlying stone tool making. To put it bluntly, the implemented theory that results in this case by vertical and horizontal mapping could lead to the conclusion that we have a mental architecture comparable to that of the Acheulean populations. This is the result of incongruence based on the fact that the whole mental architecture (the mind) is compared with only a fragment of the behavioral architecture (tool making). However, that same future archaeologist would also most likely find the remains of roads, rocket launch sites and abstract sculptures forged out of carbon fiber. Armed with our method and a well-formed theory, the fuller set of traces of the behavioral systems that made up our material culture would lead our archeologist to infer that our mental

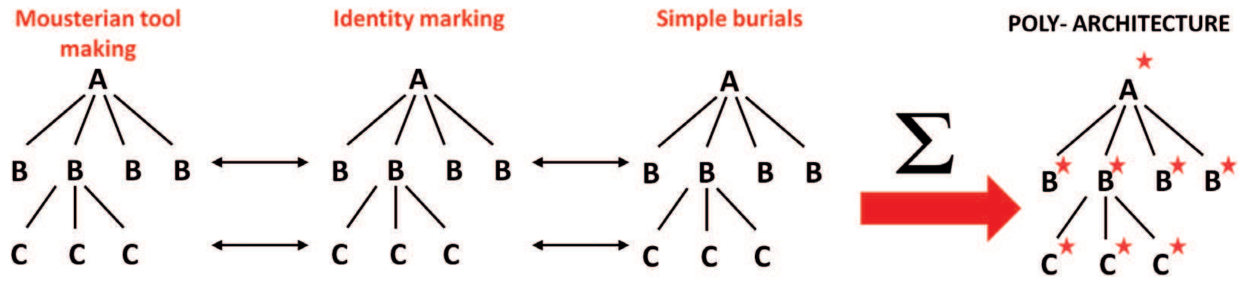

Fig. 9 - Illustration of a Poly-Architecture for behavioral systems. Modified with permission from Barnard (2010b), in Nowell & Davidson:* Stone tool and the Evolution of Human Cognition. *University Press of Colorado.

architecture was likely more advanced than those of Acheulean populations. Further examples of incommensurability linked with improper construction of architectures will be discussed in later sections.

A solution to incommensurability that can emerge from the use of incongruent architectures can capitalize on wider variation in a behavioral system that we noted earlier. The many and varied behavioral practices that are part of a species' repertoire can be used to *repeat the mapping process* and counteract the problem of incompleteness in a single behavioral architecture. The final conclusion from such a sequence of operations would be the same as a proper mapping with congruent architectures. However, in our view this process is not necessary and can be avoided by simply integrating all iterations in a single poly-architecture. A poly-architecture can be defined as the addition (Σ) of all the individual behavioral practices and systems in a synthetic architecture that accounts for the entire behavioral repertoire (Fig. 9) as well as for the entire brain circuitry (not represented).

The poly-architecture [A*] is the aggregate of the partial architectures and the same strategy is used for all the subsystems within the layers of reference of the same architecture. Each [B*] now stands for all the behavioral processes that are at the base of a single practice, while the [C*]s are the constituent elements that interact to produce those processes. This extension of Barnard´s diagram now allows us to correctly construct architectures, so that they will be congruent and the resulting horizontal mapping will be coherent, as well as the final stage of vertical mapping for the construction of an implemented theory (Fig. 5). In further developments of this methodology, the logic of such aggregations could be open to more formal representation within the mathematics of set theory. If the horizontal mapping and the construction of the meta-theories are coherent, then it means that the call for explanations from the core-level is correct as well and the mapping can then produce candidate implemented theories, that can be properly submitted to the criteria for selection for plausibility we specified earlier.

Problem of universality

Up to this point, our agenda has been focused on the attempt to define a universal methodology for CA at the normative level. In the next sections, we will shift to the descriptive level in order to create a concrete perception of concepts and mechanisms that have been rather abstract until now. In particular, we will compare the methods adopted in current CA theories with the methodology discussed in previous sections. Our goal is to provide examples of theories that conform to our proposal and theories that instead do not and therefore need to be adjusted.

As it will become clear from what follows, a significant proportion of theoretical outcomes in CA conform, at least in part, with our proposed methodology. Indeed, several theories contain parts that are commensurable and of comparable efficiency. Here, we will focus on Mithen´s (1996) modular hypothesis, Coolidge

& Wynn´s (2005) Enhanced Working memory and Barnard´s (2010a) Interacting Cognitive Subsystems. We will show that while their respective macro-theories of cognition differ among the three core-theories, the principles on which these architectures have been assembled are consistent. The proposals are therefore commensurable at least within the level of cognitive architecture. At the same time, the behavioral architecture depicted by these core-theories seems to be quite invariant, opening to the possibility of a proper comparison that includes more than one system. Since there is a paucity of evidence concerning the detail of neural architecture at present, it will not be included in the following discussion on commensurability. A great deal more research will be necessary to fill in the gaps in evidence, as well as to explore correspondences between our methodology and the extant theories in CA.

In 1996, Mithen advanced an account for CA based on evolutionary psychology and the modularity of mind argument (Barkow *et al.*, 1992; Buss, 2005; Pinker, 1997; Plotkin, 1997; Fodor, 1983; Gardner, 1983). According to his model, human mind evolved from a series of isolated domains of knowledge, also referred to as "multiple intelligences". These domains gradually became more interconnected with the increasing complexity of the genus *Homo*, until modern humans developed a module for metacognition. This had the ability to manipulate information flows between the other domains of intelligence. In this way, modern humans, but not Neanderthals, evolved a fluid cognition that enabled them to innovate and develop the wide range of Upper Paleolithic artifacts.

Coolidge & Wynn (2001, 2005, 2009) advanced a proposal, based around a quantitative aspect of Alan Baddeley´s tripartite working memory model. This architecture is composed of a central executive and two slave subsystems: the phonological loop and the visuo-spatial sketchpad (Baddeley & Hitch, 1974, Baddeley & Logie, 1999; Baddeley, 2000, 2001, 2003). Coolidge & Wynn argued that selective advantage would have accrued to *Homo sapiens* with an increase in working memory capacity. This would have allowed our species to perform a simultaneous integration of more complex information. In their view, indeed, a genetic mutation in brain networks at 90-50 kya may have enhanced working memory capacity and, in consequence, the development of complex tools and behaviors.

An alternative to Coolidge and Wynn´s model has been recently advanced by Philip Barnard (2010a) with his Interacting Cognitive Subsystems model (ICS). Within this perspective, evolution of the mind has been described as an additive process: cognitive architectures gradually became more complex via the addition of new reciprocally interacting subsystems. These developed as a result of both biological and embodied cultural dynamics. New subsystems depend on an iterative mechanism where inputs coming from two sources (e.g.: audition and body states feeding back changes in vocal musculatures) are mapped together in multimodal space, to establish their invariants that can bind them together (in this example, the invariants that underlie vocal output and heard speech is "phonology"). Once a repertoire of invariants differentiate from the bulk of other multimodal invariants, a new, functionally independent subsystem emerges (Barnard *et al.*, 2007). The proposal is that an architecture of six interacting subsystems can fully explain the behavioral repertoire of apes, as well as that of our last common ancestor. Three additional modules, for vocal articulation, phonology and for propositional meaning, were added. This last addition brought into existence not only propositional meaning, but also augmented precursor multimodal capabilities to effectively yield two levels of meaning. This in turn enabled a dialogue between the two levels of meaning that support abstract thought and innovation. Barnard´s mental architecture can do more things at one and the same time than precursor architectures with fewer subsystems. A nine-interacting subsystem architecture can walk, talk, chew gum *and think* at the same time. Across the trajectory from six to nine subsystems, the computational power of the full architecture increased and with that the behavioral repertoires they were capable of exhibiting.

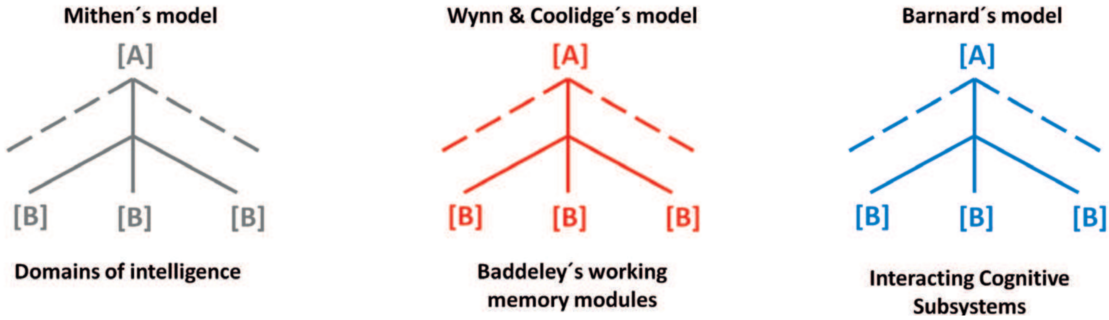

Fig. 10 - Apparent isomorphism between the mental architectures, as drawn out from the a posteriori analysis of Mithen´s, Wynn & Coolidge´s and Barnard´s models.

There is good reason to argue that these mental architectures *are* commensurable and could be properly compared. Indeed, even though the nature of the Basic interactors [B]s varies among the various models, the architectures are constructed by adopting the same logic. This suggested isomorphism between the three mental architectures is shown in Figure 10.

In Mithen´s evolutionary psychology model, the mental architecture [A] would be represented by a series of intelligences, which would act as basic interactors [B]s and would be constrained eventually by a series of evolutionary determined constituents [C]s. In Coolidge & Wynn´s proposal, conversely, the basic interactors would be covered by the subsystems in Baddeley´s model (visuospatial sketchpad, central executive, phonological loop), composed themselves by subcomponents (for the phonological loop: articulatory rehearsal and phonological store, perhaps), while in Barnard´s model the mental architecture would be represented by the interacting subsystems (the [B]s), which are composed themselves by a number of constituent subcomponents (their internal structure), which stand for the [C]s.

If we consider, as we argued earlier, that an invariant behavioral architecture can be constructed for these three different proposals, we have the possibility to map horizontally at least two systems (i.e.: the mental and the behavioral) in a coherent way. As a consequence, we have three different core-theories, which, albeit only partial because of the absence of the neural architecture, can be used to produce properly comparable implemented theories. The efficiency of these resulting implemented theories can be judged in a two stage process. First, in the construction of the core-theories, attention would be focused on internal congruence of the architectures, conformity to the experimental data, explanatory power during the horizontal mapping, etc... Second, during the vertical mapping for the target-level, the resulting implemented theories would be evaluated for their plausibility. In this way, the number of *ad hoc* hypotheses that need to be produced in order to support the explanations of the properties of the two missing systems (Fig. 5) will be counted. In summary, these three commensurable theories can be compared and analyzed through the criteria for selection that we previously discussed. Thus, theories providing less efficient explanations could be ultimately rejected.

Unfortunately, apart from the small number of implemented theories reported above, many proposals in CA do not fit with our methodology. On the contrary, most of them appear to be largely incommensurable with those described above. This general incommensurability has been noted, for instance, by Wynn & Coolidge (2011), who highlighted the fact that ambiguous terms like “complex” or “modern” cognition are widely adopted nowadays by archaeologists interested in the evolution of mind and behavior. Indeed, these notions are often used in place of precise descriptions of the cognitive processes and mental architectures necessary to produce artifacts (see also Dubreuil, 2011). For example, the elaborated sequence of stages that are necessary for performing a Levallois reduction could be considered as a proof of underlying "complex" cognition. However, this tells us little, for instance, about the working memory capacity that is needed to perform the same tool-making task. As a consequence, this difference in analytic categories clearly contributes to confusion within debates.

Problems like these stem from the fact that many theories in CA focus only on the properties of the artifactual record. Thus, properties of a behavioral architecture, or even isolated fragments of it, are used to directly draw inferences about an ill-defined structure of the mind (e.g.: complex mind, modern mind, etc...). No micro-theories of the subcomponents of the mind itself and the macro-theory that rules their reciprocal interactions are taken into consideration. In our view, this leads to a series of situations like the first type of incommensurability, where logical connections and mappings are produced with a theory-dependent logic. For instance, Barnard (2010b) reports that his diagram has a high risk of being misused through what he defines as "diagonal connections" between components of the architectures, as opposed to proper horizontal mapping. He discusses a case where specific properties of cognitive subsystems are inferred directly from isolated components of behavioral architectures. As an example of improper diagonal connections, he uses the attempt to infer properties of language from regularities in stone knapping procedures (Holloway, 1969), which is addressed without any horizontal reference to a theory of cognition.

Particular emphasis in discussing problems of incommensurability should be given to the spread use of the concept of "behavioral modernity" in the archaeological debate, an expression that itself comes with a high degree of ambiguity: there is no solid theory to account for it (Henshilwood & Marean, 2003). The main risk with attributing the label "modern" to a behavioral architecture is that it can lead to the automatic transfer of this qualitative attribution to the mental and neural architectures as well. Again, this can be performed without taking the exact nature of neural and cognitive architectures required to support the behavioral repertoire itself into consideration. For instance, defining the behavior that can be identified only in anatomically modern humans as modern tells us little about the "modernity" of the mental architecture. Even if a particular set of behavioral practices is detected exclusively in *Homo sapiens*, in fact, the cognitive processes underlying them can be thoroughly consistent with a more primitive mental architecture (Klein, 2003).

Problems like these become even more relevant when we consider the relativistic drifts that in turn plague the same notion of behavioral modernity. This is strictly dependent on the authors´ beliefs and is not based on objective criteria (see Nowell, 2010 for an extensive review; Soffer, 2009, p. 45). Modern behavior has been largely associated with the use of symbols (Chase, 2003, 2006; Davidson & Noble 1989; Noble & Davidson 1991; Henshilwood & Marean, 2003; Gamble, 1999; Marean, 2007; Wadley, 2001), but it could be possible to raise the threshold of the concept of modernity to agriculture, the advent of writing systems, or even to communication through the Internet (Chase, 2003). Or perhaps we have never been modern, as suggested by Latour in his homonymous book (1993). It appears then that it is extremely difficult to classify behavior under the qualitative category of "modernity" and any assumption in this direction inevitably holds a certain degree of arbitrariness, which grows exponentially when transferred to the domain of cognition.

From these premises it follows that attempts to infer the presence of a modern mental architecture from "modern" behavior are unsafe in principle. They ought to be replaced with proper horizontal mapping, as proposed by Barnard´s extended model.

Case Studies

Neanderthal symbolism

An example of incommensurable proposals in the extant cognitive archaeological theory might be useful to build a clear perception of the problems previously accounted for. Both Nowell (2010) and d´Errico & Stringer (2011) recently reported on the most prominent schools of thought associated with the evolution of human behavior and mind. Of the three current schools of thought recognized by these authors, we find the situation with the "cultural" school (Chase, 1999, 2003, 2006; Hovers *et al.*, 2003, 2006; d´Errico *et al.*, 1998; d´Errico, 2003; Conard, 2008; Kuhn & Stirner, 2007; Zilhao, 2007) particularly interesting for our discussion on incommensurability. This school is known for claiming that demographic changes in human populations might have been the main cause of variation in human behavior instead of cognitive or genetic factors. The rise in innovations is explained by appealing to the growing number of inter-individual interactions within a wider community (Shennan, 2001; Powell *et al.*, 2009). A striking example that might be ascribed to this framework is the recent Zilhao *et al.*´s (2010) work on symbolic cognition in Iberian Neanderthals, associated with the findings of perforated beads in Mousterian layers. These artifacts resemble those found with modern humans in Africa and in the Near East during the Middle Stone Age (d´Errico *et al.*, 2005, 2008, 2009; d'Errico & Vanhaeren, 2007; Bouzouggar *et al.*, 2007; Marean *et al.*, 2007; Bar-Yosef *et al.*, 2009.; Vanhaeren *et al.*, 2006) as well as in the European Upper Palaeolithic (Klein, 2008; Vanhaeren & d'Errico, 2006).

The authors discuss the implications of the use of beads, which they consider to be symbols *a priori*, without providing a description of the semiotic relationship between objects, signs and interpretants (Peirce, 1839-1914 in Hoopes, 1991; Rossano, 2010; Deacon, 1997), which is desirable to precisely define the structure of behavior. Then, they draw directly conclusions about the cognitive level, as demonstrated in the following passage taken from the same Zilhao *et al.*, 2010 (emphasis added):

> *"The symbolic implications of body painting and of the ornamental use of pigment-stained and perforated marine shells are uncontroversial in UP and later prehistoric contexts but, as shown by the evidence from Africa, the Near East and now Iberia, both behaviors first occur in the MP/MSA. Their emergence in two continents, among two different lineages and, in the time scale of human evolution, at about the same time,* is inconsistent with cognitive-genetic explanations *and implies that these innovations were fulfilling a need—aiding in the personal or social identification of people—that did not exist in the preceding two million years of human evolution. Our findings therefore support models of the emergence of behavioral modernity as caused by technological progress, demographic increase, and social complexification and show that there is no biunivocal correlation between "modern" anatomy and "modern" behavior (pp. 13, 36–38)."*

From the quoted text, it seems clear that the authors are using beads to argue that Neanderthals posses the ambiguously defined trait of ´´behavioral modernity``, which in this case is identified with symbolism on the base of "growing consensus" (Marean, 2007, p. 367; see also Nowell, 2010). Behavioral modernity, warranted by the use of beads, is thus used to infer that - cognitive/genetic mechanisms are not necessary to produce those behaviors typical of fully modern humans only. On the contrary, the authors conclude that even more archaic populations can develop behavioral enhancements by relying solely on demographic and social changes. However, no information is provided on which cognitive architecture is necessary or sufficient to produce body ornaments like beads. Nor the authors clarify how this architecture is influenced by the variation of demographic and social dynamics in Neanderthal populations. Furthermore, paleoneurological evidence (Bruner, 2003, 2004, 2008, 2010, 2011; Gunz, 2010), which would argue in favor of a cognitive and biological hypothesis, is also not taken into consideration. This is even more evident through the absence of any reference to a neural architecture.

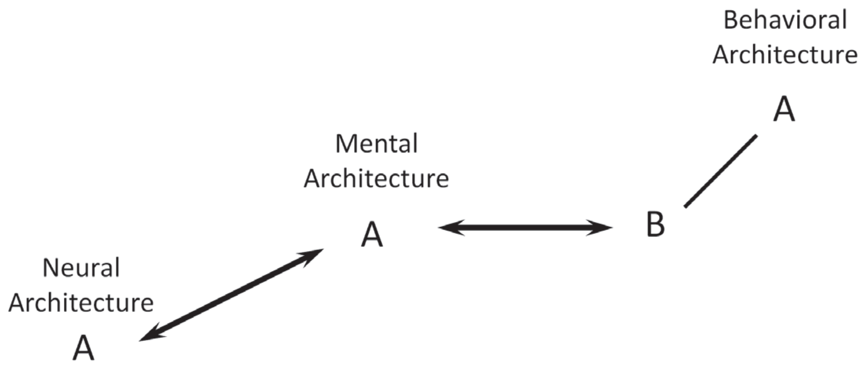

Fig. 11 - Mapping logic adopted by Zilhao et al. (2010). Modified with permission from Barnard (2010b), in Nowell & Davidson:* Stone tool and the Evolution of Human Cognition*. University Press of Colorado. The colour version of this figure is available at the JASs website.

In the light of our methodology, it can be argued that the logic adopted by Zilhao *et al.* (2010) is based on establishing connections between a part of a behavioral architecture, an isolated B (use of beads in Neanderthals), directly to an improperly defined structure of the mind (A = symbolic). In Figure 11, indeed, we can now visualize how a partial behavioral architecture is mapped on the whole structure of the mind, without taking into account any macro-theory or micro-theory for a mental architecture (Incommensurability of the first type).

In addition, even if mapped with a mental and a neural architecture, the logic is still incongruent in constructing the architectures (incommensurability of the second type) (Figure 12). As discussed before, single behavioral practices, considered in isolation from the entire behavioral repertoire, cannot be used alone to explain properties of a cognitive architecture.

The inappropriate mapping adopted by Zilhao *et al.* (2010) leads to the claim that a qualitatively modern cognitive architecture might have been present in Neanderthals as well (Harrold *et al.,* 2009, p. 290) and discovered or exploited through changing demographics/cultural phenomena. This implemented theory radically contradicts the general conclusion shared by Mithen´s, Coolidge & Wynn´s and Barnard´s models, despite being incommensurable with them. These three proposals, albeit with consistent theory-specific differences, share the idea that cognitive/biological differences were in play among modern humans and the non modern populations.

The crucial point to grasp here is that the cultural school´s conclusions could be contradicting the alternative proposals only by virtue of the improper mapping adopted and *not* because they represent more plausible explanations. Once a proper mapping is adopted, the new constraints offered by the many macro and micro-theoretical levels introduced can undermine the stability of the same theory. In what follows, we will show how properly built core-theories could in principle explain the use of beads by archaic populations without supporting the cultural school thesis of cognitive equivalence.

Indeed, we can adopt Barnard´s extended diagram to construct a proper behavioral architecture, which includes the use of beads as a basic interactor, along with all the repertoire of practices and the constituent interactors that constrain them. Then, if we map this onto a mental architecture and its subsystems, as previously described, and then on a neural architecture, we can realize that the cultural school conclusions does not follow necessarily from the use of beads. In fact, all the processes that are required to produce the Neanderthal behavioral architecture (poly-architecture), including those that underlie the use of beads, could be supported by a non-enhanced working memory, an architecture of eight interacting cognitive subsystems or a set of intelligences lacking metacognition (Coolidge &

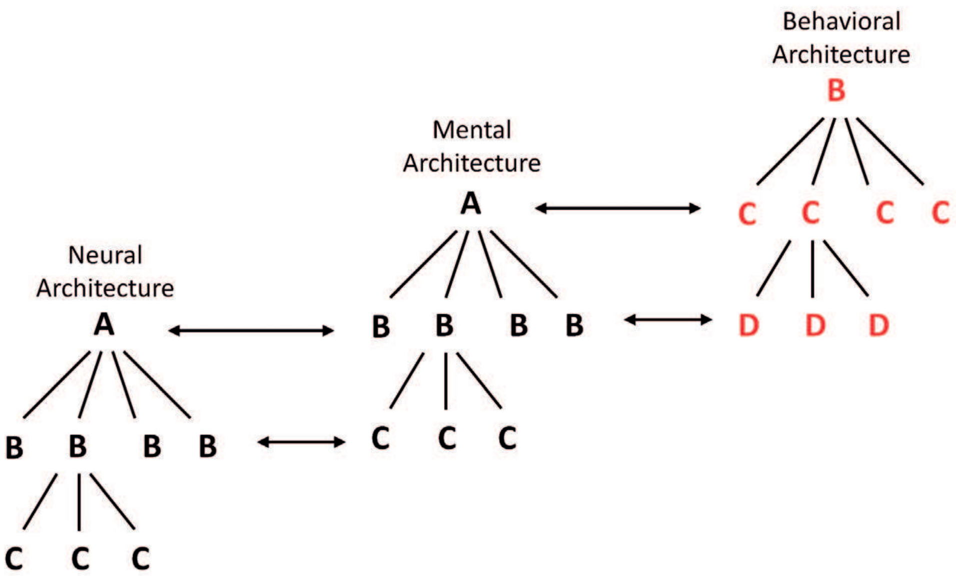

Fig. 12 - Example of an incoherent mapping produced by assembling incongruent architectures. Modified with permission from Barnard (2010b), in Nowell & Davidson:* Stone tool and the Evolution of Human Cognition. *University Press of Colorado.

Wynn, 2004; Wynn & Coolidge, 2004; Barnard, 2010a; Mithen, 1996). Contrary to the common archaeological notion that symbolism is connected with beads, this behavioral practice could be, in effect, reduced to a non-symbolic level following a Saussarian framework (Gärdenfors, 2011), an enactivist perspective (Malafouris, 2007, 2008b), or more precisely to an indexical one, by adopting a Peircean semiotics approach (Rossano, 2010, 2011). In this way, cognitive processes at the base of indexical reference can be identified, mapped on the mental architecture and evaluated together with the rest of the behavioral practices associated with Neanderthals.

By virtue of the universal laws that bind the architectures in the core-theory, the vertical mapping then allows us to reconstruct the missing architectures by presenting an explanatory set of theories in the target level, which ends up in the formation of an implemented theory (Fig. 5). In this case, if the use of beads does not exceed those cognitive processes that can explain the rest of the behavioral architecture too (see Coolidge & Wynn, reply to Henshilwood & Dubreuil, 2011), there is no need to argue in favor of a modern mental architecture in Neanderthals. However, the idea that demographic changes can lead to behavioral advancements, as hypothesized by Zilhao *et al.* (2010), can still be supported, if behavioral variations are performed within the limits of the capabilities of a non-fully-modern mental architecture. This, however, does not rule out the fact that biological alterations might have been necessary to reach a fully modern mental architecture. In addition, it does not prove either that demographic changes alone are responsible for the "discovery" of cognitive capabilities in non-modern human species.

Nevertheless, we do not intend to say that the approach of the cultural school cannot be followed or does not deserve any consideration *a priori*. Our goal was simply to compare this school of thought with the other models described above, in order to discuss an example of how theories can be incommensurable and contradictory at the same time. Moreover, we intended to point out the fact that some theories, once contextualized in a proper mapping framework, can lose their original explanatory power.

Incidentally, it appears that all the models we have argued to be commensurable in our methodology actually support the same final conclusion. However, this does not imply that our methodology is necessarily linked to the sole cognitive/biological explanatory models. This might be an additional reason for the followers of the "cultural" school to adjust their proposals in a way that is commensurable with the other models. For example, they would need to specify more clearly: a) what happens to mental and neural architectures when the behavioral one varies in response to demographic and social changes, b) which constraints prevent a modern cognitive architecture from being exploited in the absence of demographic changes, c) how current macro-theories of cognition explain the discovery of latent cognitive processes, d) what the difference in parietal lobe anatomy between modern humans and Neanderthals means (Bruner, 2004, 2008, 2010) and so forth. On the other side, the cultural school can contribute to our methodology by providing a framework to define an assembled system of social and demographic mechanisms/theories (Shennan, 2001; Powell *et al.*, 2009). This could exert further constraints on the behavioral architecture and on the whole process of generating core-theories.

Based on this approach, it would be possible to create candidate implemented theories, which might be properly compared with alternative theoretical proposals and evaluated for plausibility in light of our criteria for selection. In the current state of affairs, the fact that the cultural school offers theories that are mostly incommensurable with those from the other schools of thought demonstrates that methodological relativism represents the *status quo* in cognitive archeology. This example embodies how deeply distorted (and inefficient) a theoretical debate based on contradictory and yet incommensurable theories is.

Use of beads in early modern humans

Recently, Henshilwood & Dubreuil (2011) advanced a proposal on a related topic, namely the use of beads in Early Modern human populations in South-African Still Bay and Howieson's Poort technocomplexes. Interestingly, their approach to the potential symbolic implications of this practice can be considered as broadly consistent with our methodology.

The authors provide a multidisciplinary analysis of the controversial problem of the use of beads in Early-modern *Homo sapiens* populations. They describe a behavioral architecture that includes the production of beads, advance explanations on the cognitive processes that are compatible with the use of beads as ornaments, and propose a neurological explanation for these cognitive requirements. Henshilwood & Dubreuil argue that beads can be considered as symbolic (p. 375) and that this explanation is supported by a series of cognitive processes that implies the presence, within these populations, of a working memory capacity that almost equals that of contemporary humans (p. 379). This is furthermore supported by other synchronic archaeological evidence (pp. 372-375 and references therein; Wadley, 2010). This hypothesis is also corroborated by their argument that there was a rise in complexity of the temporal lobes, which is in turn supported by studies in evolutionary neuroscience that show a disproportional enlargement of the temporal volumes in modern humans as opposed to apes (Rilling & Seligman, 2002; Semendeferi & Damasio, 2000). In addition to volumetric variations, they also refer to the enhanced functional characterization of temporal cortices, their pattern of connectivity and development (pp. 362-367 and references therein).

Comparing Henshilwood & Dubreuil´s proposal with that of Coolidge & Wynn (2011), it can be argued that these authors refer, more or less directly, to the same set of theories in constructing a core-theory (the same set of rules), which might be associated to Baddeley´s framework (Baddeley & Hitch, 1974; Baddeley & Loogie, 1999; Baddeley, 2001, 2003). Even though this does not exactly match our proposal for producing assembled systems, their macro-theories and the mapping processes, it is important to recognize that we agree in the methodological direction that ought to be taken. It is worth noting that every assertion these authors make with respect to behavior is connected to explanations in terms of executive functions and cognition, as well as neural substrates. This creates a series of inferences that work as a holistic network.

However, these groups of authors interpret the behavioral architecture in different ways, so that the relationships among the entities within the behavioral architecture are different (one allows symbolic exchange of information between entities, the other only indexical). As a consequence, the result of vertical mapping, along with the explanations drawn from the core-theory, both differ. In this case, the same core-theory produces different conclusions depending on how the behavioral architecture is constructed from the artifactual record. The result of this vertical mapping is the formulation of two candidate implemented theories, which are perfectly congruent in the rules of construction of the architectures, internally coherent in the mapping processes and ultimately commensurable when compared. These two implemented theories, albeit contradictory in their conclusions, can then be submitted to our criteria of selection for plausibility.

Which conception of the behavioral architecture best fits with the artifactual record? How many *ad hoc* hypotheses are requested to make the implemented theories stable? Do they leave some gaps of knowledge behind? Are they simple or is it necessary to multiply the assumptions required to support them? Questions like these can be answered now by examining the difference in the *contents* of the two implemented theories, not *their rules of construction*.

It is worth noting how the two groups of authors defend their respective models in the context of the commentary to Henshilwood & Dubreuil´s work (2011). Coolidge & Wynn claim that Henshilwood & Dubreuil´s implemented theory is implausible, because *ad hoc* hypotheses are required to associate beads with symbolism and modern cognition. For instance, to support the idea that beads are processed like true symbols, and not like indexes, it might be necessary to state clearly what the abstract concept embodied by these artifacts is, how this association is cognitively mediated, which cognitive processes are involved and how the symbol is inserted in a system of symbols that allows it to be considered this way (Deacon, 1997). Without providing a detailed account on these points, the association between beads and symbolism seems to be unjustified.

Henshilwood & Dubreuil defend their position by stating that the symbolic value of beads is explained by associating the abstract concept of "coolness" to these artifacts, as well as to contemporary ornaments like earrings, a notion that is nevertheless rejected by the former authors as an *ad hoc* assumption. Henshilwood & Dubreuil might need a further *ad hoc* hypothesis to clarify why a mental architecture, assumed to be capable of handling metacognitive tasks in the creation of symbols, kept this potential latent for thousands of years after reaching this level. From their side, Wynn & Coolidge have to deal with problems traditionally connected with every mutation-based proposal. For example, they need to provide additional clarifications on the chronology of mutational events, the speed of replacement of alleles that specify for non-enhanced working memory phenotypes, the outcome of behavioral advantages, etc... (see for a review Wynn & Coolidge, 2011).

Conclusions

Our lack of access to the mind of ancient populations, as well as the necessity of reconstructing its nature by mapping together multiple and reciprocally interacting systems, represent probably the most important epistemological issue in CA.

Scholars who have chosen to embrace a non-reductionist view and to take these problems into consideration might, therefore, be tempted to overcome them by accepting methodological relativism. In this paper, however, we have argued that the intrinsic limits of this discipline do not require scholars to adopt a subjective/interpretative approach. As an alternative to relativism, we have proposed a method based upon a synthesis of the following:

1) **Horizontal Mapping - Meta-Theoretical Level**: *The construction of universal laws of*

connection between the interacting systems examined in CA (in our case neural, mental and behavioral architectures) based upon empirical and theoretical research in extant species. These rules should allow the prediction of how any potential set of systems interacts, so that, given one system, and constraints that govern their connections, the nature of the other two can be inferred.

2) **Construction of the Target Level**: *The individuation and definition of a behavioral architecture, its own constitutive elements and the way they interact.* This operation is mediated by the analysis of the archaeological record associated with the target species/ population of interest.
3) **Vertical Mapping - Implemented-Theory**: *The deduction of missing architectures and their interactions in the target level.* This is performed via universal principles of connection determined by point 1 above, as applied to the target level´s behavioral architecture (point 2). As a result of this procedure, we have what we have defined an "implemented theory". This is not necessarily valid in the explanations it provides, because elements of implausibility can arise out of each stage of construction (point 1 and 2). However, this resulting implemented theory is logically coherent and can represent a candidate theory to be compared with other candidate proposals in terms of plausibility.
4) **Theory selection**: Plausibility of candidate implemented theories is evaluated on the basis of criteria for selection and the most plausible theories selected given our state of knowledge.

This methodological proposal demonstrates that, even in the absence of strict empirical reference, it is still possible to adopt a methodological framework that allows us to evaluate theoretical proposals on the base of rationally objective criteria, which markedly differ from subjective interpretations.

In summary, within the wider field of CA remains a risk of reintroducing relativism, which would lead to the dangerous paradox of "formalizing" the idea that anything goes. To counter this risk, we have proposed an extension of Barnard´s (2010b) model. Our proposal provides a precise logic to be followed when mapping domains of knowledge in CA. This method is still incomplete and may include additional assembled systems. Nevertheless, we argue that it is not only more efficient than any relativistic perspective, but it is also necessary in order to allow candidate theories to be properly compared. In this way, the risk of comparing incommensurable theories, built from different epistemological bases, can be avoided. Indeed, incommensurability can lead researchers to use a subjective methodological perspective to correct or ignore possible conceptual problems that arise within a theoretical proposal. In addition, adopting a distorted methodology can lead scholars to focus their attention and efforts on models that might be flawed in their contents. These models can be perpetuated by virtue of this methodological flaw, but can then divert effort and focus away from properly constructed models.

Of course, it is not our position that all the studies in cognitive archaeology which are not aligned with our proposal should be totally dismissed. Even works focusing on single or partial architectures can, in fact, contribute valuable new evidence, problems and questions concerning the nature of the systems of interest. These elements can be nonetheless contextualized within our model and can contribute to the formation of more inclusive and more properly constituted theories.

In addition, we are not claiming that our approach is the only one admissible as a universal methodology in this discipline. Instead, we hope to stimulate the development and the discussion of further techniques able to provide more efficient methodological tools than those discussed here. In our view two points are absolutely critical: i) providing efficient ways of establishing logical connections between/within assembled systems and ii) proposing rational criteria for evaluating commensurable theories. These elements represent the foundations of an anti-relativistic agenda and must be adhered to.

Proposals like ours are inevitably affected by the problem of dealing with real communities of scientific practice. These are usually prone to self-determination of their own methods and often unresponsive to potential suggestions of changes from outside their communities (Bell, 1998). However, our short-term goals are two-fold. First, we hope that this paper will drive the attention of cognitive archaeologists to the problems discussed here, encouraging new ideas. Second, we wish to provide a tool for identifying theories that carry elements of incommensurability and that consequently need to be further developed.

Glossary

Architecture: An aggregated system of structural entities that interact by virtue of their properties, creating a behavioral outcome.

Arcuate Fasciculus: A neural pathway that connects posterior regions of the brain (temporo-parietal junction) with the frontal cortex.

Core-theory: An abstract representation that defines a level where all the meta-theories are integrated together, in order to highlight the invariant rules of system interaction that are valid for all the considered species. The result is a theory that accounts for how neural, mental and behavioral systems interact and constrain each other in all potential conditions, given the evolutionary links that connect organisms.

Horizontal mapping: The process of aligning architectures and establishing connections between their constituent parts which follows a universal logic that is determined *a priori*.

Implemented Theory: The entire theoretical schema that results from the process of horizontal and vertical mapping and provides explanations about the nature of ancient minds.

Incoherence: In general, this term has been adopted to define a distorted mapping procedure. More specifically, in the horizontal mapping, this is the result of mapping between incongruent architectures or diagonal inferences that put layers that are not allowed to interact into communication (due to differences in the mapping rules between systems). In the vertical mapping, this indicates both the propagation of an incoherence in the horizontal mapping phase, as well as the assumption of different rules for mapping architectures between the core and the target level.

Incommensurability: This occurs when two or more implemented theories, each with different rules for mapping between and within systems, are built and thus cannot be compared because of the differences in the methods of construction.

Incongruence: A term adopted to describe using of different rules of construction for single architectures, where the internal layers are built by referring to different levels of reference, so that each hierarchy is different than the others (i.e.: different in terms of the rules of construction within each system).

Level: The imaginary context where architectures are aligned and mapped together by virtue of their properties.

Macro-theory: A theory that structures a system of local theories in a holistic whole and not the sum of reductive units.

Meta-theory: A set of theories that are mapped together for a single species of interest and predicts how the constituent architectures interact and constrain each other in every contingent situation that characterizes that species.

Micro-theory: A theory that is generally produced in experimental situations and accounts for specific subcomponents of an aggregated system/architecture.

Post-processualism: A school of thought in archaeological theory that denied the possibility for archaeology to reach objective conclusions by adopting a scientific method. According to the post-processualists, indeed, archaeology was limited only to a subjective/interpretative perspective.

Processual School: A movement in archaeological theory that supported the idea scientific method could be applied to archaeological research. Hypotheses could therefore be advanced by collecting quantitative data and tested directly from the archaeological record.

Vertical mapping: The process of connecting a behavioral architecture based on the artefactual record to a core-theory, in order to produce explanations on the nature of extinct minds and brains.

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A.2

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Comment on “Trees and ladders: A critique of the theory of human cognitive and behavioural evolution in palaeolithic archaeology” by Langbroek, M. (Quaternary International 270: 4–14)

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ABSTRACT

In his paper “Trees and ladders: A critique of the theory of human cognitive and behavioural evolution in Palaeolithic archaeology”, Marco Langbroek puts forward an important argument against simply using linear methodologies in cognitive archaeology (CA). In this comment I shall argue that the reasons why linear models are problematic are not those proposed by Langbroek but rather lie in weaknesses in the way in which arguments based on models have generally been constructed. Top-down and bottom-up approaches in CA should not be viewed as in opposition, but rather as making complementary contributions within the generation of well-formed families of models. The real problem with linear models arises when flawed theories of behavioral systems are improperly mapped onto mental systems, on the basis of arbitrary rules of connection and unsubstantiated assumptions. Neglecting reference to precise analytic categories is a particularly crucial problem in CA, and this applies also with some aspects of Langbroek's argument. To highlight and overcome these issues with the author's original formulation, I shall suggest the formulation be augmented by implementing some recently introduced epistemic tools for CA.

1. Introduction

In his 2012 paper, Langbroek criticizes linear approaches in cognitive archaeology (CA). He argues that linear models explain behavior and cognition of extinct hominids by direct comparison to ethnographic and primatological knowledge. These comparisons are biased by the use of notions like that of “behavioral modernity”, which act as a top-down imposed Rubicon to determine what can be considered as modern and what not. In this way, he argues, explanations of behavioral/cognitive evolution are effectively decided in advance and are untestable. Langbroek proposes an alternative, bottom-up perspective in which the archaeological record is used as the unique framework to draw inferences about the nature of extinct hominid behavior and cognition. This method, albeit difficult in many respects, would discard linear views of cognitive/behavioral evolution and replace them in CA with a more evolutionarily plausible idea of trees and branches. In particular, it would reveal patterns of behavior and cognition that are typical of specific hominoids and that represent idiosyncratic traits that have no counterpart in modern humans.

However, while the issues raised by the author are important, I disagree with the reasons he offers for the flaws with linear models.

2. Top-down vs. bottom up

Langbroek argues that we need to shift our attention from *a priori* theories to “frames of reference based somehow on the archaeological record itself” (page 8), where data serve to produce theories (page 9). These statements, however, come with a certain degree of ambiguity.

The author (page 8) acknowledges that deduction is a central logical operation in CA. He refers for example to ‘Centrifugal Living Structures’ in Neandertals as “an explicit attempt to create a model of unique spatial behavior *deduced* from observations of the archaeological record itself” (emphasis added). However, Langbroek's association between inference from the archaeological record itself and the structure of deductive arguments appears contradictory. Behavioral patterns, even though idiosyncratic, can be reconstructed in the archaeological record only because they are deduced from an abstract theory of how stones, knapping techniques, human agents, and so forth interact. Once these abstract rules are in place, a set of stones and debris identified in the archaeological record is open to explanation as a behavioral system.

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Use of the record alone for drawing inferences points to an inductive dimension that is deeply problematic for CA. There seems to be no escape from the fact the archaeological record ought to be connected to body of theories of behavior and cognition, so that explanations of the nature of the processes in place can be deduced.

Deductive arguments in CA imply a double directionality of inference. The archaeological record is indeed connected bottom-up to theories. Theories in turn are used top-down to produce explanations. Crucially, this double directionality also holds for linear approaches and demonstrates that the paradigm shift invoked by Langbroek cannot be grounded in an opposition between directions of inference, nor in a conflict between theories and the archaeological record alone. The problem with linear models actually lies in the problematic principles and assumptions they adopt to formulate and assemble theories that are used then to deduce explanations on properties of extinct minds and behaviors.

To provide concrete illustrations of these points it is worth comparing the principles adopted by linear approaches with those expressed by a recently introduced methodology, namely "holistic mapping" (Garofoli and Haidle, in press). The first stage of this methodology consists of connecting up the whole repertoire of behavioral systems assembled in the archaeological record for a particular species to an abstract network of theories. This network specifies rules of connection between neural, mental and behavioral systems, so that changing the local structure of one system will propagate the change to other linked systems by virtue of the connection rules. In other words, this level tells us that a particular brain structure can be reliably associated to a particular cognitive architecture, which is in turn capable to handle a specific set of behaviors. Once a behavioral system is reconstructed in the archaeological record and mapped to this network, explanations of the nature of extinct minds and brains are then deductively inferred from this level. In the second stage, the gamut of explanations produced in this way is then abductively evaluated against other candidate theories, by adopting criteria of plausibility.

It is important noting that within this approach, knowledge from ethnography and primatology is not directly and analogically used to explain the archaeological record. Rather, it is used to create a network of abstract theories of how inter-related neural, mental, behavioral systems interact for all cases and conditions. The structure of this logic is schematically represented in Fig. 1 for behavioral and mental system (neural system not represented).

In marked contrast, linear models do not connect archaeological record to networks of theories, but to theoretical levels that are partial, isolated or improperly connected. Their theories of behavior do not embody abstract principles of interaction between entities in a behavioral system. On the contrary, they depict partial theories that are constructed from and explain only fragments of ethnographic and primatological evidence. As shown in Fig. 2, these theories are then used to define a higher theoretical level of "behavioral modernity", which expresses then a rule of connection between behavioral and mental systems. Using Langbroek's example, "home bases" patterns are identified in the ethnography of modern humans and used to define a prototype of modern behavior. This behavior is then connected to modern cognition as a postulate (diagonal emboldened arrow in Fig. 2). Then, a behavioral pattern in the archaeological record is assessed in relation to this standard. If sufficiently similar, inferences on modern cognition follow automatically from the rule of connection; if not, the connection leads to a primitive mind.

It is clear that both of the methodologies just illustrated proceed by connecting the archaeological record to some theoretical level and vice versa.

However, besides the aforementioned use of fragmentary versus abstract theories, a notable difference between the two approaches lies in the use of analytic categories and mapping principles that are broadly incommensurable.

In the case of holistic mapping, behaviors reconstructed in the archaeological record are assembled in behavioral architectures. These represent systems of entities characterized by precise properties that interact and constrain each other (e.g.: a human, expert agent performing Levallois reduction). They are then mapped to a mental architecture, in order to deductively infer properties of other interactors in the mental system that are necessary and sufficient to handle them (Barnard et al., 2000; Barnard, 2010a). Here is the key problem. Behavioral modernity does not represent any single property of behavioral architectures. It is not a principle of interaction between human agents and stones, nor does it represent a particular technique implemented in stone tool making, nor does it define any information flow among entities. Since it does not refer to any of these properties of behavioral entities it is unclear how this notion can be reasonably mapped on properties of cognitive architectures.

Furthermore, in holistic mapping, properties of cognitive architectures stem *a posteriori,* as a product of the logical analysis performed during the mapping procedure with behavioral architectures (represented by the double edged emboldened arrow in the top of Fig. 1). In contrast, with linear approaches, when the behavior reconstructed from the archaeological record is found to match with a prototypical modern human behavior, the inference to modern cognition is automatic. Indeed, it is *a priori* decided by the connection rule "modern behavior → modern cognition" (i.e.: diagonal arrow in Fig. 2), which does not involve any analysis of the properties of cognitive architectures.

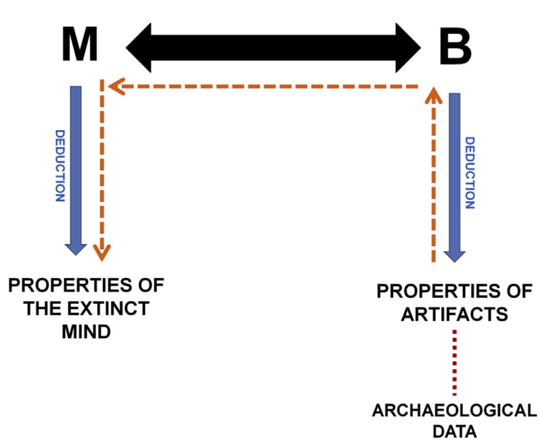

Fig. 1. The logic of "holistic mapping" for behavioral (B) and mental (M) systems. Neural system not represented.

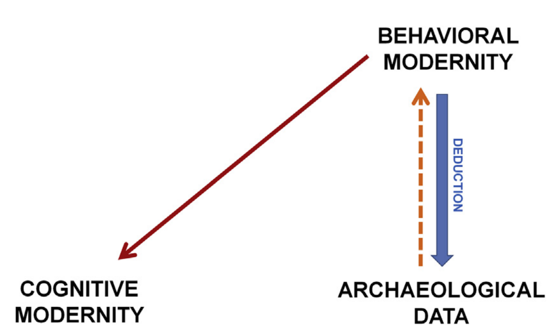

Fig. 2. The logic of linear approaches. The emboldened diagonal arrow represents an axiomatic connection between behavioral and cognitive modernity.

The problem Langbroek reports with theories that *a priori* bias data is therefore not focused on top-down connecting theories to the archaeological record. Rather, the crucial flaw in linear models lies in the adoption of theories that are incommensurable with those assembled by proper mapping in CA. These theories are in fact grounded on analytic categories that have no clear foundation in the cognitive science domain, as well as bridged with arbitrary assumptions.

3. Backfire: underspecified analytic categories

The absence of reference to a strict epistemic logic, like holistic mapping, leaves Langbroek's argument exposed to aspects of his own criticism. Using "complexity" (e.g.: page 8, 9, 12) as a criterion to evaluate reconstructed behavioral patterns and then to infer properties of extinct minds can be problematic. Indeed, complexity does not define precise properties of behavior that are then mapped on properties of mental architectures. On the contrary, it is an imprecise or ambiguous concept that is once again open to *a priori* manipulation in order to produce explanations that are biased in advance. If not responding to precise analytic categories that define behavioral and cognitive properties, purely subjective judgments can be advanced about the level of complexity of a behavioral practice. Such interpretations can lead to unwarranted inferences concerning mental capabilities.

This problem becomes particularly acute when evaluating traits that may have no counterpart in modern humans. There can be little doubt that many behavioral patterns of non-modern humans can appear to be extremely intricate (see the author's case study 2, for example). However, we need to be aware of the tendency to attribute cognitive modernity to hominids capable of showing behavioral patterns that "seem" quite complex. To avoid this problem, the notion of complexity must be replaced by analytic categories that define precise entities (and their properties) in behavioral, cognitive and neural systems.

Applying holistic mapping to patterns of behavior in the archaeological record can reveal properties of a cognitive architecture that are necessary and sufficient to account for a target behavioral system that do not necessarily require a modern mind. For example, in the second case study taken into account by Langbroek, the Neanderthal behavioral pattern can be mapped, together with other behavioral systems detected in their material culture, to a cognitive architecture that exhibits some specific properties. By way of illustration, if we take Barnard's Interacting Cognitive Subsystems model (Barnard et al., 2007; Barnard, 2010b) as framework for cognitive evolution, that behavior could be explained by referring to a mental architecture that predates a fully modern one by relying on a single system for processing meaning. An extreme increase in neural and cognitive capacity in the Neanderthal systems could be sufficient to explain that behavioral pattern, without referring to the capabilities instantiated in a fully modern mental architecture which Barnard argues has not one, but two types of module for processing meaning. This reveals an autapomorphic Neanderthal trait – which is indeed increased in capacity and can carry more information, producing new behavioral patterns. At the same time, this hypothesized rise in "complexity" is performed without necessary referring to a qualitatively modern architecture. Putting aside the issue of the validity of this particular theory and explanation, which must be separately discussed, the critical point lies in the fact that an increase in complexity can be arbitrarily linked to alternative cognitive mechanisms, leading to dramatically different outcomes. Holistic mapping enables us to clearly specify the nature of these mechanisms and hence the space in which well-formed decisions among options can be made. While helping to overcome the problems with linearity, this methodology also allows us to avoid the pitfall of ascribing cognitive equivalence to non-modern humans on the basis of underspecified analytic categories.

4. Conclusions

Langbroek wishes us to abandon linear methodologies in CA. The idea of creating categories such as "modern" and "primitive" and using them to advance explanations of the archaeological record is misguided. The deep reasons for flaws with linear methods, in my view, lie elsewhere. Top-down and bottom-up approaches are not mutually exclusive in CA, as he would have us believe, they are thoroughly integrated within the dialogue between the archaeological record and theoretical debate. The problem with linear models lies instead in adopting flawed methods to assemble theories of behavioral systems that are then used to draw inferences on mental capabilities by adopting arbitrary rules of mapping. This arbitrary aspect, and not the existence of a theoretical level to be used top-down, best embodies the *a priori* bias individuated by the author. By applying holistic mapping, the attention becomes focused on specific properties of interactors and systems, whilst notions like behavioral modernity and complexity, that have no precise definition in the cognitive science jargon, become irrelevant to the debate.

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Cognitive archaeology without behavioral modernity: An eliminativist attempt

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ABSTRACT

During the last decade, evidence of artifacts typically associated with the European Upper Palaeolithic has gradually accumulated in the archaeological record of early modern human and late Neanderthal populations. These artifacts, in particular instances of "symbolic" body ornaments, have been considered proof of "behavioral modernity" and used to draw inferences about the cognitive equivalence between primitive and modern human populations. Very recently, however, proponents of holistic mapping and material engagement theory have provided two separate lines of argument criticizing the notion of behavioral modernity and its use in cognitive archaeology. Major problems with this concept have been identified at both the epistemological and metaphysical levels. In this paper I will articulate a critique of behavioral modernity by integrating the preliminary tenets of the aforementioned approaches within a unitary perspective. This integrative process will provide close examination of behavioral modernity under the lights of scientific eliminativism. I will argue that behavioral modernity fails to instantiate a natural kind and thus it cannot be the object of reliable scientific analysis. Furthermore, behavioral modernity does also not represent a useful functional kind, for it offers no explanatory role in the mapping of artifacts and mental architectures. The current use of behavioral modernity in cognitive archaeology is grounded in a series of arbitrary categories and unwarranted inferences. In consequence, this notion can, and in fact, does harm this domain, because it fosters incommensurable theories. For these reasons, I conclude that behavioral modernity ought to be eliminated from the cognitive archaeology vocabulary.

1. Introduction

1.1. The ontology of behavioral modernity

The concept of behavioral modernity (henceforth BM) has progressively acquired a central role in the archaeology of Middle-to-Upper Palaeolithic transitions. During the last thirty years, a great number of scholars have embraced the idea that some technologies and cultural practices identified in the archaeological record could be considered as "behaviorally modern" and contrasted with archaic behaviors. Initially, BM was used to classify a set of behavioral practices (e.g. cave art, specialized tools, complex social organization, extensive trade networks, musical instruments, ivory figurines, complex hearths) that supposedly emerged with anatomically modern humans in the European Upper Palaeolithic (Bar-Yosef, 2002; Mellars, 2006; Klein, 2008). The dominant paradigm advocated that modern behavior and modern anatomy coevolved at ca 40 ka in Europe (Mellars and Stringer, 1989). However, during the last two decades, several lines of evidence have led to a reconsideration of the initial convictions. Paleoanthropological evidence has shown that the roots of modern human anatomy date back to ca 200 ka in the African Middle Stone Age (White et al., 2003; McDougal et al., 2005; Aubert et al., 2012). At the same time, artifacts that were previously considered as typical of the European Upper Palaeolithic appeared significantly often in several African sites from ca 100 ka (Conard, 2008). Thus, the findings of bone tools, ochre engravings, bladelets, and perforated beads that were explained as early forms of body ornaments upset the central tenets of the traditional paradigm. First, this evidence

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illustrates that modern behavior is decoupled from modern anatomy, since these two aspects are separated by a hypothetic lag of 100 ky. Second, the gradual accumulation of these artifacts in the record was adopted to show that BM was incrementally acquired within a long time scale and did not imply any revolutionary event of the kind previously associated with the Upper Palaeolithic (McBrearty and Brooks, 2000).

To complicate the picture, artifacts/behaviors comparable with those present in modern human African sites, like pierced shell-beads (Zilhao, 2007; Zilhao et al., 2010; Zilhao, 2012), raptor talons potentially having an ornamental value (Morin and Laroulandie, 2012), or the presumed non-utilitarian removal of feathers from birds (Peresani et al., 2011; Finlayson et al., 2012), have been reported in some Neanderthal sites in Europe. This evidence led some scholars to support the idea that BM extended beyond modern human anatomy and applied to archaic human populations as well. Consequential multispecies models explaining the origins of BM were proposed, according to which Neanderthals also started to develop their own Upper Palaeolithic material culture (d'Errico, 2003).

The great relevance of BM and the broad adoption of this concept in the archaeological domain generate a fundamental question. What do we mean by behavioral modernity? In probably the most systematic treatment of the topic, Nowell (2010) has recently attempted to answer this and other crucial interrogatives. By meta-analyzing the conceptions of BM currently adopted in archaeological literature, this author attempts to identify a representative concept of BM based on its description in literature. Results from this analysis indicate that the criteria defining BM are multiple: a unified theory specifying the meaning of BM is absent from archaeological theory.

A first general approach to identify BM was based upon constructing lists of behaviorally modern traits. These lists aimed to capture the innovative behaviors that emerged as a consequence of specific events in human evolution. BM was therefore identified with a series of new practices that either abruptly emerged in the context of the European Upper Palaeolithic, were coupled to the rise of *Homo sapiens*, or caused hypothetically by a discrete mutational enhancement of the human brain (see Chase, 2003 and references therein).

Nevertheless, the gradual emergence of behaviorally modern artifacts in the African Middle Stone Age led to the abandonment of criteria based on clear-cut thresholds. This new evidence, though, did not upset the traditional tendency to define BM as a list of traits. Such a list, however, had to be accommodated to the new requirements imposed by gradualist models. McBrearty and Brooks (2000), for example, proposed a series of more general categories, which were able to represent the common aspects shared by Upper Palaeolithic typical modern behaviors and their more basic instances in the Middle Stone Age. Following d'Errico (2003) these categories are: (a) abstract thinking; (b) planning depth; (c) behavioral, economic, and technological innovativeness; and (d) symbolic behavior. Archaeological enquiries therefore focused on identifying artifacts and cultural practices of modern human and archaic populations that could fit within this new classificatory schema.

Despite being likely the most traditionally adopted approach (Harrold, 2007; d'Errico and Stringer, 2011), a list-based conception of BM, in the absence of clear-cut thresholds, contains the intrinsic problem of relativity. If, as postulated by McBrearty and Brooks (2000), the African Middle Stone Age displays a slow transformation of primitive technologies into the more advanced Upper Palaeolithic ones, when and where can we pinpoint the emergence of BM? What counts as modern? Levallois core reduction, for example, is thought to require a great degree of planning in preparation of the core before performing the single blow which detaches the final product (Pélégrin, 2009). Currently, however, few scholars consider this technology as behaviorally modern, because it does not show a similar degree of planning depth as more recent technologies like traps (Wadley, 2010) or bow-and-arrow (Lombard and Haidle, 2012) do. If criteria are grounded in quantitative aspects, then a priori decision on the, say, quantity of abstract thought or planning that is necessary and sufficient to consider an artifact as modern clearly leaves room for relativism. List-based criteria, indeed, have been argued as not universal and therefore inevitably arbitrary (Chase, 2003; Soffer, 2009; Belfer-Cohen and Hovers, 2010).

Interestingly, Nowell (2010) argued that the vast majority of archaeologists nowadays concede BM ought to be identified as symbolically mediated behaviors (Davidson and Noble, 1989; Noble and Davidson, 1991; Stringer and Gamble, 1993; Wadley, 2001; Chase, 2003, p. 637; see also Chase, 2006; Henshilwood and Marean, 2003; Henshilwood, 2007; Marean, 2007; Soffer, 2009; Texier et al., 2010; Barham, 2013). This way of thinking introduces a second general approach to BM, which consists not of a list of traits, but defines the essence of what it means to be human. Such an essence depicts the critical aspect that “distinguishes moderns from the ancients” (Stringer and Gamble, 1993, p. 207, quoted by Nowell, 2010). This defining trait is generally recognized as the construction of symbolically mediated social lives, ranging from linguistically mediated behaviors to the storage of symbolic information in material culture (Barham, 2013, p. 347). In particular, Henshilwood and Marean (2003) argue that identifying BM by means of European Upper Palaeolithic lists of traits is conceptually inadequate. Drawing from Wadley (2001), they provide essence-based criteria identifying “fully symbolic sapiens behavior” within the material culture of extinct populations. Such an alternative approach, however, does not come without problems.

1.2. Behavioral modernity in cognitive archaeology

The BM debate assumed great relevance in the cognitive archaeology domain, where great interest was focused on explaining the mechanisms underlying the emergence of behaviorally modern artifacts. The initially proposed revolutionary model was particularly synergic with the idea that a discrete mutation in the neural architecture of early modern humans was responsible for the technological revolution registered in the Upper Palaeolithic (Klein, 2008, 2009).

In contrast, the presence of behaviorally modern artifacts in the material culture of early modern humans, far predating the European Upper Palaeolithic, was used by the cognitive equivalence agenda to show that a mutation in the mental architecture was not required for the production of BM artifacts. Modern humans emerged from a speciation event at ca 200 ka, equipped with a modern cognitive architecture and acquired BM along an incremental trajectory that connects the African Middle Stone Age artifacts/behaviors to the European Upper Paleolithic ones (McBrearty and Brooks, 2000). In contrast, partisans of the “cultural school” (Speth, 2004; Zilhao, 2007, 2011a, 2011b; Burdukiewicz, 2014; Villa and Roebroeks, 2014) contend that the emergence of BM does not follow a unique line of development, but takes place along multiple trajectories, defined by different times, modes, locations and peculiar combinations of behaviorally modern traits (see Conard, 2005; d'Errico and Banks, 2013). At the same time, such multiple trajectories are not necessarily incremental, but they often follow patchy distributions, characterized by the appearance and disappearance of BM traits preceding a full consolidation of these practices (Hovers and Belfer-Cohen, 2006). Most importantly, the presence of behaviorally modern artifacts, like ornamental

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beads, in some European Neanderthal sites has been adopted by the "cultural school" to claim that also Neanderthals were acquiring BM along their own idiosyncratic trajectories. The differences in the cultural trajectories among human species and populations are explained by referring to a combination of demographic (Shennan, 2001; Powell et al., 2009), environmental (d'Errico and Banks, 2013) and cultural (Gelfand et al., 2011; Sterelny, 2011) phenomena, rather than by cognitive/genetic differences. In consequence, the bricks of the same mental architecture are assumed to have been already in place since the Middle Pleistocene (for review see Harrold, 2009 and d'Errico and Stringer, 2011).

The cognitive archaeological debate was therefore focused on detecting the presence of behaviorally modern artifacts in the archaeological record of extinct human populations, in order to draw inferences about the minds behind their manufacturing. Most importantly, behaviorally modern artifacts have been broadly assumed to prove the existence of a modern mind in their makers. Such an inference was implicitly justified by referring to Franz Boas' (1940) principle of uniformity among living people (Conard, 2010). According to this tenet, modern humans universally display a specific set of behaviors, which entail the existence of the same psychological mechanisms. Projected onto the archaeological record, instances of material culture that fall within the range of modern behaviors are considered to prove the existence of a modern cognitive architecture also in these extinct populations. Archaeological literature is thus replete of cases where artifacts considered as behaviorally modern led to the formulation of cognitive equivalence theories.

However, recently some approaches grounded in cognitive science and philosophy have advanced critical arguments against the current use of BM in cognitive archaeology. They have either argued that BM cannot be adopted as an epistemic tool to connect artifacts to mental systems or they have questioned the very existence of BM at a metaphysical level. In consequence, the entire cognitive archaeology debate might be affected by problematic aspects that could compromise its validity. These proposals, however, remain preliminary and need to be further elaborated upon before a solid line of argument against the use of BM in cognitive archaeology can be assured.

2. Aims of the paper

In this paper I offer an integrated synthesis of two recent critical arguments: holistic mapping (Garofoli, 2013a; Garofoli and Haidle, 2014) and material engagement theory (Malafouris and Renfrew, 2009; Malafouris, 2013). Such a synthesis would serve to expose the most problematic aspects with the current use of BM in cognitive archaeology. On the grounds offered by holistic mapping, I will show that the use of BM is incommensurable with a reliable mapping method in cognitive archaeology and it leads to logical circularity. Relying on material engagement theory, I will argue that BM biases the debate in a modern-centric way and it can survive only by adopting neurocentric and deterministic assumptions. Such problems will be illustrated by focusing on archaeological examples, particularly early body adornment. Most importantly, these critical aspects serve to ground a more radical criticism of BM. This notion will be analyzed with the tools of scientific eliminativism (Griffiths, 1997; Machery, 2005, 2009). I attempt to demonstrate that BM fails to represent a natural kind. Therefore, it cannot be appropriate for scientific analysis. At the same time, I will show that this notion cannot even survive as a functional kind. BM does not fulfill any explanatory role in the mapping of artifacts with mental architectures and thus represents a poor functional category for cognitive archaeology. Despite these limitations, it might be possible to save BM only insofar as it is still useful to the cognitive archaeology domain. However, by virtue of the problems discussed in the first half of the paper, I will conclude that BM is detrimental for cognitive archaeology and that its maintenance is unjustified.

3. Behavioral modernity and cognitive archaeology: some critical problems

3.1. Holistic mapping and the problem of incommensurability

Garofoli and Haidle (2014) have recently urged for an epistemological reform in cognitive archaeology. In their view, this domain is threatened by deep forms of relativism, which may reduce any theoretical debate to a sterile exchange of invaluable opinions. In response, these authors propose "holistic mapping" as a logical method to select plausible theories out of a gamut of logical possibilities. Holistic mapping makes a fundamental assumption, which resonates with some principles of the processualist/conditional school of cognitive archaeology (Bell, 1994; Renfrew, 1994; Abramiuk, 2012, pp. 31–33). The scope of cognitive archaeology lies in defining the minimum requirements extinct minds would have needed to produce specific technologies within the archaeological record. The method aims to accomplish this goal through two phases. In the first, deductive stage, behavioral practices reconstructed from the record are initially assembled in "behavioral architectures" (Barnard, 2010a). Thus, the interactions between humans and artifacts that take place during the realization of a practice are identified and organized in multilayered systems (e.g. Haidle, 2009, 2010, 2012 and; Lombard and Haidle, 2012). The chains of action and perception at the basis of each practice are made therefore evident. For example, Levallois reduction can be assembled in a "behavioral architecture", by analyzing the sequence of operations required to prepare a core and detach a finished flake with a single blow. Such systems of behavioral operations are then mapped onto a more general theoretical level (Barnard, 2010a). This level explains the universal relationship between brains, minds and behaviors at the very basis of the evolutionary principles connecting these systems (which are considered to be immanent properties, see Wolverton and Lyman, 2000). In this way, a series of alternative cognitive properties that suffice to explain these practices in the record are deduced from this general level of theory (see Garofoli and Haidle, 2014, p. 15). Referring again to Levallois reduction, it could be possible to deduce at least three distinct logical possibilities for detaching a flake from a prepared core: a) language representations are adopted in order to develop a mental plan based on if-then arguments, b) visual imagery, rather than linguistic propositions, is employed in order to support the realization of such a plan, and c) the material structure of the core resonates with embodied actions previously performed and directly brings forth a series of operations, without the need to mentalize a plan in any form (see Robbins, 2006, for a description of "direct memory").

In a second, abductive stage, the gamut of logical possibilities that stem from the analysis of an isolated behavioral practice is contrasted with the whole behavioral repertoire of a species (which realizes the holistic aspect of the mapping process). As a result of this comparison, the minimal explanations that are both necessary and sufficient to account for a behavioral practice in the record are selected for their plausibility. The explanations that stand as only sufficient and that constitute exceptional or unique cases in the context of a species' behavioral repertoire are then considered mere logical possibilities and eliminated until contrary argument is provided. It is certainly possible, for example, that Acheulean bifacials are symbols, which might stand for concepts like BEAUTY or PERFECTION, used in mate-selection. However, insofar as we have more parsimonious explanations (i.e. bifacials are tools, see Nowell and Chang, 2009) and no other instance of Acheulean material culture constrains the existence of such abstract concepts, we have no reason to accept the hypothesis that Acheulean bifacials are symbols. Cognitive explanations are therefore selected on the basis of how well they fit within a network of theory, rather than by empirically testing theories against the archaeological record (Hodder, 2005, chapter 7; Shanks and Hodder, 1995). Thus, the abductive stage of holistic mapping takes the form of a context-based hermeneutics, close to the approach advocated by the post-processual tradition (Hodder and Hutson, 2003; Johnson, 2010, chapter 7). In this way, holistic mapping lies in between processual and post-processual schools, seeking to reach scientific knowledge in cognitive archaeology while opposing both relativism and positivism (VanPool and VanPool, 1999).

In relation to the problem of BM, this brief summary illustrates an important point. Explanations about which mental architecture is necessary and sufficient to produce artifacts result from a rational analytic process. Importantly, such a process entails a set of inferential steps that connects properties of behavior to cognitive processes and then to features of mental systems. In contrast, the vast majority of the approaches in cognitive archaeology do not conform to these analytic requirements. The broad adoption of BM as an epistemic tool in cognitive archaeology has led scholars to neglect any analysis of the cognitive processes necessary and sufficient to produce artifacts and how these processes are realized by mental architectures. On the contrary, BM has fostered the connection between artifacts and minds on the basis of intuition.

3.2. Case studies

To illustrate the difference between holistic mapping and the current approaches in cognitive archaeology, let us consider the case of perforated beads and symbolism. In the current debate, symbolic artifacts are broadly assumed to prove the existence of behavioral and cognitive modernity. However, according to the logic of holistic mapping, any connection between artifacts and modern cognition requires a mapping process between instances of symbolism in the record and cognitive architectures (Fig. 1). The use of beads as body ornaments, which many authors consider to instantiate early symbolism (see discussion in Abadía and Nowell, 2014), must be decomposed into a behavioral architecture where human–artifact interactions are clearly spelled out (see White, 2007, for a first analysis of the operations required for manufacturing Aurignacian ivory beads). Body adornment must thus be described in terms of the hypothetical behavioral phases that take place between the collection of a shell to its use as a body ornament. Such a behavioral chain must also depict the motivational components that encouraged the adoption of shells as body ornaments. Behavioral and motivational components can be mapped onto cognitive properties that are necessary to realize them (e.g. what kind of mental representations are required (if any); which social-cognitive processes are implemented; which working memory or attentional bases are required, or whether language is involved or not, etc.). Cognitive properties, in turn, can be ultimately mapped onto theories of mental architectures that are necessary and sufficient to bring them about (Barnard, 2010b). In this way, it could be inferred whether or not a modern mental system is required for beads to be produced, where modernity refers here to a specific organization of cognitive architecture, such as the ability to create meta-representations.

The current approach in cognitive archaeology replaces this analytic phase with a set of intuitions motivated by "perception of complexity" in early body ornaments. Perforated beads are intuitively considered to be symbols. Symbolism is then classified as behaviorally modern on the basis of a list of traits or an essence previously defined. From this level, an automatic inference allows a connection between early body ornaments and a modern cognitive architecture (Garofoli, forthcoming; Malafouris, 2013, p. 184; see also Iliopoulos, in this issue, on a similar problem).

This method is non-analytic, because it does not offer any analyses of behavioral systems and cognitive mechanisms, nor does it map onto theories of cognitive architectures (see also Wynn and Coolidge, 2007, for a similar point). In contrast, it simply sorts artifacts into a BM category based on some postulated "criteria for modernity". Such criteria, organized in lists of typical behaviors or built around "modern essences" are unrelated to cognitive abilities and properties of mental architectures. However, inclusion in the BM category via these criteria is used to conclude that modern cognition is present (Fig. 2). Such an approach represents an emblematic case of BM leading to the neglect of any analysis of cognitive processes involved in artifact creation.

Some authors, at least implicitly, recognized the absence of attention for cognitive analysis and attempted to fill this lacuna, despite retaining BM as an epistemic tool. In particular, McBrearty and Brooks (2000) adopted a list-based approach which brought attention to some more cognitively shaped "criteria for modernity". However, their approach only displaced one problem with another. For the sake of argument, let us consider their category of "in-depth planning" to the archaeological case of bark-pitch hafting, which Zilhao (2011a) considers as an innovative and original Neanderthal behavior. Following this logic, we might say that this practice is evidence of a degree of action planning such that it can be considered behaviorally modern. That is, "in-depth planning" is now the new signature property for modernity. This might be argued in turn to support an extreme thesis about Neanderthal cognitive equivalence. Nevertheless, this reasoning is plagued by

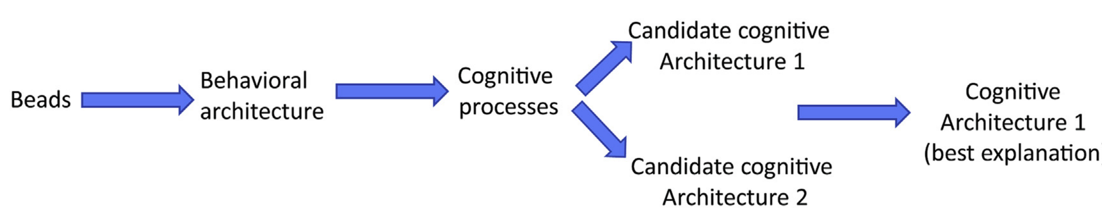

Fig. 1. Network of inferences employed by the holistic mapping method to connect beads with the best theory of cognitive architecture, which is necessary and sufficient to explain the existence of such artifacts in the record.

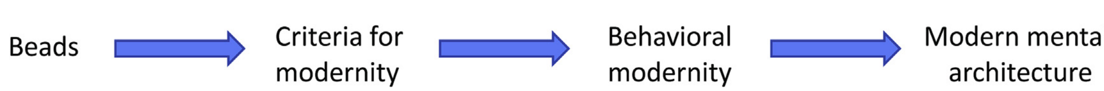

Fig. 2. Chain of inferences used to connect beads to modern cognition by adopting behavioral modernity as an epistemic tool.

two problems. First, the category of planning is still too broad for identifying specific cognitive mechanisms and cannot be reliably mapped onto candidate theories of mental architecture (Fig. 1). Second, the proposed inferential chain implies that in-depth planning automatically requires modern cognition without performing any mapping onto theories of mental architectures. The connection between hafting, planning depth and mental systems is again based on intuitive grounds and thus stands as a dogma. Hence, McBrearty and Brooks' (2000) approach only changed the nature of the criteria for modernity shown in Fig. 2. Indeed, they replaced an a priori list of behavioral traits (e.g. hafting, ornaments) with an a priori set of more cognitively oriented aspects (e.g. planning, symbolism). In sum, traditional approaches that aim to identify behaviorally modern artifacts and to infer directly from them properties of mental architectures are incompatible with the holistic mapping method and based on unwarranted inferences.

3.3. Circular logic

The non-analytic approach currently adopted in cognitive archaeology carries with it an even more critical epistemological problem. Automatic inferences that connect BM with cognitive modernity inevitably lead to logical circularity. I can illustrate this problem by referring to the case of shell beads and symbolism in Neanderthal populations (e.g. Zilhao et al., 2010). The argument for cognitive equivalence takes the following form:

a) Behavioral modernity implies cognitive modernity
b) Symbolism implies behavioral modernity
c) Beads are symbols
d) Some Neanderthal populations are associated with beads
e) Hence: Neanderthals are behaviorally modern
f) Hence: Neanderthals and modern humans share the same cognitive architecture

This chain of inferences assumes as a premise that symbolism (i.e. body adornment in this case) implies behavioral and cognitive modernity. This assumption, however, is exactly the point at stake in cognitive archaeology. The proposition "using beads necessarily requires properties of a modern cognitive architecture" ought to be supported by assembling a behavioral system of ornament-use and by mapping it onto a theory of how minds work (Barnard et al., 2000; Barnard, 2010a). As a result of this analysis, it might indeed turn out that this form of body adornment does *not* require modern cognition for its realization. If early body ornaments can be produced by more primitive mental systems (Garofoli, forthcoming), many of the theoretical tenets advocated by cognitive equivalence become problematic. The presence of beads in the record would not suffice to rule out cognitive differences between Neanderthals and modern humans (Zilhao et al., 2010). Such a hypothetical scenario shows that the relationship between beads and modern cognition can only emerge as a result of an analytic process. On the contrary, by assuming an automatic connection between some categories of artifacts, a notion of BM and cognitive modernity, the result of the cognitive archaeological analysis is already established in advance (Wynn and Coolidge, 2007; Langbroek, 2012; Abadía and Nowell, 2014). Such an approach, thus, is logically circular and leads to invalid conclusions.

3.4. Tyranny of modernity

The previous discussion introduced an important point. In cognitive archaeology, the same behavioral practice identified in the record could be realized in principle by means of alternative cognitive strategies. In turn, such cognitive processes might require different cognitive architectures to be implemented (Garofoli, 2013b; forthcoming). However, in the current archaeological debate, such a problem of multiple realizability has been neglected over time. In contrast, scholars have assumed high-level mentalistic processes as default explanations for behaviors in the record. Thus, cognitive processes that are acquired by contemporary humans, enculturated in historical societies, have been projected back in the past and adopted to explain instances of material culture in a modern-centric way.

In his formulation of material engagement theory, Malafouris (2013) has recently defined a similar problem as the "tyranny of modernity". This bias openly violates a fundamental principle in the entire domain of comparative psychology, which resonates with the logic of holistic mapping. We cannot explain the mental properties of a living being in terms of high-level cognitive processes if we have a low-level explanation that is also well constrained by empirical evidence (Morgan, 1903).

Tyranny of modernity presents an additional related problem. According to Malafouris (2013), high-level cognitive processes are acquired by contemporary humans by means of material engagement. In this way, artifacts act as necessary scaffolding for the emergence of new cognitive capabilities along a transformative process. For example, the modern human ability to mentally manipulate images of animals and use them to draw pictorial representations is the product of a previous stage of enactive engagement with pigments. By exploring a cave wall with fingers drenched in color, human agents come to gradually discover that a curved line resembles the back of a horse. This initial gesture, in consequence, does not presuppose the existence of a mental representation that is first visualized in memory space and then copied onto the cave wall. Rather, that very explorative action represents a necessary condition to acquire a representation of an animal. In this way, the fact that contemporary humans can mentally manipulate images of animals and use them as models for their paintings cannot be used to explain the capabilities of primitive human populations. Precisely because such representational capabilities do exist in contemporary populations, we have to assume material scaffolding and non-representational forms of engagement existed prior to (and led to the emergence of) such high level abilities. The same conception applies to other behaviors that are broadly considered to prove the existence of BM. Let us consider the case of symbolism. If modern humans do have symbols we need to think to past stages of non-symbolic material engagement with artifacts that led to the gradual emergence of fully symbolic abilities. In consequence, in line with Malafouris' (2013, chapter 8) position, the presence of beads in the archaeological record of early modern humans and late Neanderthals should count as evidence *against* symbolism. The only way early body ornaments can be explained as symbols (as a default hypothesis) lies in assuming that the process of gradual cognitive transformation underlying material engagement is unnecessary. In this way, symbolism can abruptly rise in human evolution as a result of genetic mutation targeting specific neural regions and cognitive modules. This change comes with high metaphysical costs. It implies that the mind ought to be conceived as a "Swiss-army knife", constituted by domain-specific modules that are hard-wired by natural selection in order to solve specific adaptive issues (e.g. Mithen, 1994, 1996). In this way, BM represents a set of behaviors coupled with the rise of the modern mind. Considering BM through this extreme evolutionary psychology account leaves room to deterministic and neurocentric views, according to which human behavior and culture are mere byproducts of brain evolution and passive Darwinian mechanisms (Knappett and Malafouris, 2008; Tallis, 2011; see discussion in Oestigaard, 2004).

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These tenets of material engagement theory complement the holistic mapping method. While holistic mapping seeks out the necessary and sufficient properties that are required to produce certain technologies (i.e. the what?), material engagement theory focuses on the necessary conditions for the emergence of a technology on the long time scale (i.e. the how?). The bridging of holistic mapping and material engagement theory consists in identifying how cognitive properties vary within the transformative process driven by the engagement with artifacts. A thorough integration of the aforementioned approaches requires shifting the attention from brain, minds, bodies and artifacts, considered as isolated systems, to hybrid cognitive architectures constituted by the blending of these components into a unitary system (Wheeler and Clark, 2008).

Regarding the identification of necessary and sufficient properties to turn shells into body ornaments, two considerations are relevant. At the semiotic level, material engagement theory implies that beads ought to be considered as non-symbolic material scaffolds, rather than as full-symbols. Accordingly, at the level of cognitive realization, holistic mapping considers enactive social perception (Gallagher, 2008; Hutto, 2011), rather than full-blown mindreading (see Apperly, 2011, for review) as a default strategy to be evaluated against the record (Garofoli, forthcoming). This methodology gives priority to a social cognitive strategy based on the direct perception of embodied emotions directed towards a collected shell, which serves to ground the meaning of the item and to motivate the adoption of the shell as a body ornament.

In contrast, the tyranny of modernity bias leads scholars to take on high level mentalistic explanations, such as abstract concepts and full-blown mindreading (e.g. Henshilwood and Dubreuil, 2009, 2011). These abilities are often empirically unconstrained and incompatible with the logic of material engagement (Garofoli, forthcoming). Furthermore, as the case of full-blown mindreading illustrates, such abilities are often not even primary in contemporary humans (de Bruin and de Haan, 2012), but are paradoxically considered as such when used to explain the behavior of extinct populations.

4. Scientific eliminativism

In the previous sections I discussed problems with the notion of BM, in particular when used to draw inferences between artifacts and mental systems in cognitive archaeology. Elements of the previous analysis now act as a basis for examining BM with the tools of scientific eliminativism (Griffiths, 1997; Machery, 2005, 2009, 2010). The aim of the following analysis is to demonstrate that: a) BM does not count as a natural kind and b) this notion does not play any role in the process of holistic mapping previously described.

4.1. Natural kinds

Scientific eliminativism aims to demonstrate that a notion or concept does not count as a natural kind and therefore cannot be the target of reliable scientific analysis. Natural kinds have a long metaphysical tradition. A review of the current literature (Pöyhönen, 2014) suggests that the following list of criteria has been adopted to define natural kinds:

1. Induction justification: Natural kinds should license inductive inferences.
2. Causal grounding: Natural kind concepts should track the causal structure of reality. The unity of a kind is causal, not conceptual.
3. Non-analyticity: Members of a natural kind share a large number of (logically unrelated) non-trivial properties in addition to the ones that are used to identify the kind.
4. Semantic open-endedness: The semantics of natural kind terms is such that it makes sense to attempt to refine their meaning through empirical inquiry.
5. Lawfulness: Natural kinds are referred to in laws of nature.
6. Essentialism: Natural kinds have essences constituted by their intrinsic properties.
7. Uniqueness: There is a unique best taxonomy of reality in terms of natural kinds that represents nature as it is.

I refer here to the theory of natural kinds advanced by Richard Boyd (1990, 1991; see also Machery, 2005, 2009), which is currently favored by the academic consensus (Samuels and Ferreira, 2010). According to a loose account of this theory, a scientific concept does count as a natural kind when a class of entities can be included into a kind by means of inductive generalization (crit. 1). Furthermore, such entities must share the same causal mechanism (crit. 2). A stricter version of this approach (Machery, 2009, 2010) implies that members of a natural kind must also share a set of unrelated non-trivial properties besides those used to define the kind (crit. 3) and that the natural kind can be informed by empirical research (crit. 4).

According to this theory, water is considered a natural kind, since samples of water share many properties, due to the fact they consist of the same molecules of H_2O (Machery, 2009). It could be added that the physical properties that rule the relationship between oxygen and hydrogen at the molecular level represent the causal condition that make a substance part of the natural kind water. Furthermore, samples of water share non trivial properties that go beyond such a causal principle (e.g. viscosity, ebullition and freezing point, etc.). These properties are empirically discoverable and support the making of generalizations.

Natural kinds do not only apply to the natural sciences, but also extend to the human sciences, provided that the target of enquiry can be identified with the same criteria introduced above (Boyd, 1991; Pöyhönen, 2014). For example, feudal economy represents a natural kind for comparative economics, since it is based on a series of social organization principles and human relationships that are causally relevant to all feudal societies. These principles can be discovered and refined through empirical research. Moreover, the natural kind “feudal economy” can be used for understanding the organization of newly discovered societies, or for drawing analogies between historically and geographically distinct social organizations, such as medieval England and imperial China (Boyd, 1999).

The principles and aims of scientific eliminativism are well captured by the following passage from Machery (2009, p. 200):

> In a given science, the scientific classificatory scheme is developed to identify the natural kinds in the relevant domain because identifying these kinds allows scientists to discover new generalizations. Scientific classificatory schemes are modified when they do not identify the relevant natural kinds (as happened during the chemical revolution in the eighteenth century), and scientific notions are often eliminated when it is found that they fail to pick out natural kinds.

In relation to the cognitive archaeological debate, we might wonder first whether the notion of cognitive modernity counts as a natural kind. I have contended elsewhere (Garofoli, 2013b) that, in contrast with Malafouris (2013), cognitive modernity could resist elimination. I agree with Malafouris that conceiving the human mind as an evolutionary determined mental architecture, constituted by innate representational modules, is no longer tenable. However, arguments against hard-wired domain-specificity do not suffice to reject other forms of nativism (Elman et al., 1996). According to the neuroconstructivist perspective advocated by Malafouris (2010, 2013), the notion of modern mental architecture could survive when considered in terms of domain-relevance (Mareschal et al., 2007; Karmiloff-Smith, 2009). Innate properties lie in the constraints of the multilayered (i.e. embrained, embodied, ensocialed) process of human development. These constraints can take the form of the physical properties a network of neurons (integrated in a bodily system and situated in the world) natively has, which impose limits to the network's functional plasticity. Cognitive architecture, therefore, emerges as the result of a dynamic trajectory of development, which is influenced by native constraints within the system (Elman et al., 1996, pp. 27–30; Johnson and de Haan, 2011, p. 14). Different domain-relevant mental architectures, situated within particular trajectories of development, can acquire the capability of processing thoroughly new levels of meaning (Barnard, 2010b). Deep qualitative differences can thus emerge between different mental architectures, which cannot be explained by referring to recycling or augmentation of previously existing functions within the same mental architecture. For example, the construction of meta-representations (e.g. I know that you know) could require a system able to process regularities that are qualitatively different from those involved in the production of simple coordinated propositions (e.g. “the horses are in the valley”), where concepts of horses and valleys are labelled by linguistic tokens. The cognitive system processes regularities between concepts and tokens, and structures propositions where various linguistic representations are meaningfully connected one to another. In contrast, a meta-representational system constructs linguistic representations having propositions as a target. This distinction appears to be qualitative, since it is based on a difference between the types of regularities processed (i.e. propositional vs. meta-representational code). In contrast, a quantitative variation implies that new and potentially more complex meanings are built on by processing the same invariant code, such as coordinated linguistic propositions. Quantitative variations are therefore related to plastic rearrangements within a cognitive system, rather than to the addition of qualitatively different components. Furthermore, the possibility of meta-representing aspects of the world does not necessarily follow from the fact that a system can build propositional meaning. It cannot be therefore ruled out that this shift requires biological alterations in the structure of the brain. Thus, it is possible to imagine a scenario where only modern humans, and not Neanderthals, for example, have evolved a brain capable of constructing meta-representations.

The proposal introduced above, though open to debate, could be used to define a minimal sense of modern cognition. This minimal sense differs from the traditional one introduced by evolutionary psychology and broadly adopted by archaeologists for the following reasons:

a) Modernity does not represent a hard-wired mental architecture, provided with a series of innate modules. Rather, the modules emerge as a progressive specialization of domain-relevant regions within the brain (Mareschal et al., 2007).
b) Modernity is not directly caused by alterations within the brain, nor can it be bound to a specific time period identified within the archaeological record (Iliopoulos, in this issue).
c) Modernity cannot be evaluated in terms of quantitative differences between cognitive systems (e.g., Coolidge and Wynn, 2005), since alterations in the relative “capacity” of a cognitive function do not allow to set clear thresholds for modernity.

The minimal sense shares with the traditional one only the fact that there could exist cognitive functions, like meta-representations, that are realizable only with a *Homo sapiens* brain and are qualitatively different from those realizable by, say, a Neanderthal. This conception still presents some potential problems, because the word modernity carries an intrinsic element of teleology and invites to believe that some cognitive architectures are “superior” to some other ones, rather than being simply different. Thus, it would be in any case preferable to name these architectures on the basis of their qualitative properties, such as, for instance, propositional vs. meta-representational architecture. However, for the sake of the argument, I will keep using here the term “modern” as a label to identify a hypothetic mental organization that is only realizable within a modern human brain/body system.

This architecture should count as a natural kind. The very history of the emergence of one model of cognitive architecture, the Interacting Cognitive Subsystems model (Barnard et al., 2007; Barnard, 2010b), shows that this theory has been produced by empirical research providing multiple sources of evidence (Barnard, 1985; Barnard and Teasdale, 1991; Sheppard and Teasdale, 1996; Su et al., 2011). The interacting subsystems that are part of the model are derived by means of inductive inferences (crit. 1). They describe a general organization of the human mind, despite the many shapes possible, including extreme cases of difference (Everett, 2005, 2012). Although many concepts used to define a mental architecture are functional/explanatory notions (e.g. the concept of interactor), certainly such models can be refined by experimental research (crit. 4). In fact, modules are considered to have properties like capacity, which can be measured at a psychometric level (Barnard et al., 2000). Furthermore, these properties are causally grounded, for they are produced by a set of similar causal mechanisms, at least at the functional level (crit. 2). These cognitive architectures can share many functional properties besides being constrained by the same innate properties (crit. 3).

In case one wishes to accept this “minimal sense” of cognitive modernity as a natural kind, the next question is: can we do the same with BM? I will argue that the answer to this question should be no.

4.2. Behavioral modernity and natural kinds

In order to speak of BM as a natural kind, we should first understand what kind of causal mechanism is adopted to define this concept. The point lies here in identifying a causal mechanism that binds together instances of modern behaviors identified in the record. Focusing on list-based approaches, it is necessary to identify the causal roots of, say, bladelets, early body ornaments, hafting and bone tools. The only causal criterion that seems prima facie capable of relating these heterogenic practices appears to be their common origins. Renouncing any analytic expectation and neglecting problems of circularity, we can concede, for the sake of the argument, that a modern cognitive architecture is necessary to produce the short list of behaviors mentioned above. BM thus identifies those behaviors caused by modern cognition. “Caused by modern cognition” therefore becomes the causal principle we were looking for (crit. 2). Note, however, that causal origins alone do not suffice to make BM a natural kind. Crit. 1 in the list reported above implies that properties of artifacts should lead to the category of modernity by means of inductive inference. That is, artifacts in the record must have empirically discoverable properties that could be generalized in a category of modernity. The category of “things that can be ignited”, for example, is constructed by generalizing common properties of a class of substances that share a causal mechanism. A new substance that empirically burns can be classified within that category, which stands then as a natural kind. Inductive generalization, however, does not apply to the case of BM. In this case, modernity is not empirically discoverable and instead is

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deduced from cognitive modernity. Furthermore, if "caused by modern cognition" is the causal criterion used to identify a natural kind of BM, it is hard to imagine what additional non-trivial properties can be shared by these artifacts (crit. 3). At the same time, it would be unclear how empirical enquiry could help to refine BM (crit. 4) and lead to the discovery of unknown properties shared by the members of the BM category (i.e. artifacts and behaviors identified in the record). In this way, BM fails to satisfy three of the four criteria used to define a natural kind according to Boyd (1991) and thus cannot be considered a natural kind.

4.3. Behavioral modernity as a functional kind

One might argue that although BM cannot be considered a natural kind, this notion can survive to criticism as a functional kind. Functional kinds are often considered as notions that play explanatory roles in science, rather than being the target of scientific analyses (Lalumera, 2010; Weiskopf, 2010). Similarly, Pöyhönen (2014) elaborates on his notion of instrument kinds by arguing that these kinds are identified by a robust cluster of projectable properties supported by a causal mechanism. However, he continues, functional kinds are poor devices for reductive science, for their members do not share any non-trivial property besides the identification one. Furthermore, functional kinds, though empirically grounded, cannot be refined by means of empirical research in the same way natural kinds can. In contrast, their epistemic power lies in the ability to capture abstract mechanisms common to different targets. Pöyhönen (2014) presents the concept of EYE as an example of functional kind. To illustrate the case, consider that different kinds of eyes are realized by means of different structural and physiological properties (e.g. the limulus eye and the human eye). The concept of EYE is functional in that it plays the role of describing the abstract causal mechanisms of vision shared by different visual organs. However, given the multiple forms eyes can take in nature, empirical analyses of these different systems would not significantly add to the concept of EYE, whereas they will, however, refine the specific concepts of the human or limulus eye.

Let us now focus on the nature of the causal mechanism that might be used to identify BM as a functional kind. I have argued that a possible way to see this causal link is to consider behaviorally modern artifacts as "caused by a modern mental architecture". In that case, I have argued that even taking for granted this causal connection, BM fails to fulfill criteria 1-3-4 and thus cannot be considered a natural kind. Nevertheless, I will now turn to argue that, additionally, this same causal connection (crit. 2) is problematic.

According to the principles of material engagement theory (Malafouris, 2013, see Section 3.3) human behavior ought to be conceived as the result of the enactive engagement of human and material agents. In this way, human behavior is a property of material engagement and lies at the interface of brains, bodies and artifacts. In this sense, causality is not a prerogative of mental architectures only. By analogy, we can say that mental architectures do not cause behavior in the same sense as gravity causes graves to fall. In fact, the same domain-relevant modern cognitive architecture, situated in different cultural and natural environments, could give rise to dramatically different cognitive and behavioral outcomes. On the other hand, the same behavioral practice identified in the archaeological record could be multiply implemented by different mental architectures (e.g. the example of early body ornaments).

Material engagement theory therefore argues against the idea that a strong causal connection exists between mental systems and specific instances of behaviors. If such a causal nexus is removed, then a crucial criterion to define BM as a functional kind is also put in discussion. Such a strong causal nexus can in principle be supported only by relying on deterministic and neurocentric views, but this comes at remarkable costs.

Supporters of BM might reply by attempting the following move. They could argue that we do not need to conceive any strong causal nexus between BM and cognitive modernity. In contrast, causality can be intended in a loose sense, according to which the causal nexus between modern behaviors and mental architecture is only potential. In this case, BM would refer to the gamut of artifacts and cultural practices that *can* be caused only by a modern mind. This solution seems consistent with holistic mapping, since it applies BM to those artifacts that entail cognitive modernity as a result of an analytic process. At the same time, the fact that this approach refers to artifacts that are "potentially realizable" by a modern system conforms also to the requirements of material engagement theory. Potentiality maintains the dynamic and enactive components advocated by material engagement theory, while it allows escape from deterministic and neurocentric pitfalls.

However, even though the previous criterion of causality for BM might seem reasonable, I contend that this approach is also problematic. Being grounded in a causal criterion is a necessary but not sufficient condition for a kind to be considered functional. Machery (2010, p. 238) argues that considering something as a functional kind makes sense in regards of two aspects: a) that the functional kind is also a natural kind and b) that the functional kind is useful to the progress of the discipline where it is applied. In a similar fashion, Weiskopf (2010, p. 228) contends that "If a model containing a functional category *F* has greater explanatory and unifying power than ones that lack it, then *F* is prima facie a kind". In the context of the concept eliminativism debate, Weiskopf provides the previous argument to resist Machery's eliminativist approach towards the notion of CONCEPT. He contends that concepts cannot be eliminated, for they capture psychological phenomena that would be unexplainable without these constructs. In this way, concepts gain their status as functional kinds, by covering an indispensable explanatory role in cognitive science.

We might attempt to generalize these basic tenets to BM and check whether this notion plays an indispensable explanatory role in the cognitive archaeological domain. From a review of the traditional non-analytic approaches to BM, it becomes apparent that this notion certainly plays an epistemic role in cognitive archaeology. Either in the shape of a list of behaviors or in the form of an essence, BM was indeed used to identify modern behaviors in the record and to in turn draw inferences about modern cognition (Fig. 3a). However, if we apply holistic mapping (Garofoli and Haidle, 2014), judgments of modernity follow the result of the analysis and do not precede it (Fig. 3b).

Thus, artifacts like Mycenaean Linear B tablets (Malafouris, 2011), for example, are assembled in behavioral architectures of interacting agents, then mapped onto mental systems and likely judged to require a modern mental architecture (see also Fig. 1). Only at this point, when the analysis is completed and the explanations about cognitive modernity in these populations are in place, can these artifacts be considered as behaviorally modern. However, in this case BM does not perform any role in the process of mapping but rather emerges as a byproduct of it (fading arrow in Fig. 3). Taking a closer look, it might even be argued that BM is just a mirror notion of cognitive modernity, which simply shifts the attention from properties of mental architectures to properties of artifacts. The proposition "artifacts that are necessarily produced by properties of modern mental architectures" could also be intended as "properties of mental architectures that are necessary to produce specific artifacts". This version of BM seems therefore redundant with cognitive modernity and is epistemically vacuous in cognitive archaeology. By eliminating this notion, the mapping process is not

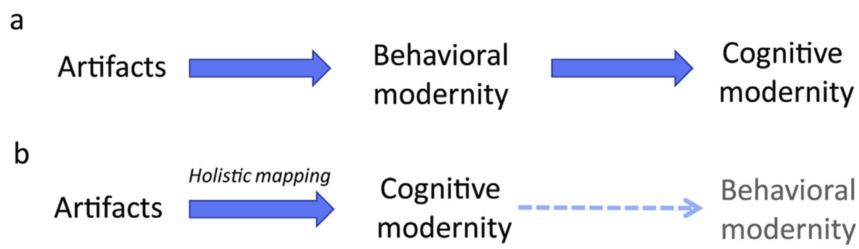

Fig. 3. Role of BM in traditional inferential models (a) vs. holistic mapping (b). From the comparison it is possible to see that in traditional model BM works as an epistemic tool connecting artifacts to cognitive modernity. In contrast, BM does not play an explanatory role in the holistic mapping process and, at best, it might be used to label artifacts that necessarily require properties of a *Homo sapiens* mental architecture to be realized. This however does not influence the mapping process.

affected and thus BM cannot be considered as a functional kind. More precisely, this notion represents a category similar to Weiskopf's (2011) "things that can be knocked over with a feather". Even though this class of objects is identified by a causal mechanism and stands as functional, such a category is scientifically uninteresting and there is no reason to consider it to be a kind.

5. General discussion

The arguments illustrated above show that BM does neither count as a natural kind nor inhabit a relevant epistemic role in cognitive archaeology. By revisiting the two main approaches to BM defined in Section 1.1, it is now possible to clarify how this notion has been improperly considered in both the approaches. As previously discussed, a broadly adopted approach to BM in cognitive archaeology is grounded in the construction of lists of behavioral traits. Such lists appear to be built with unclear and arbitrary rules, but are then used as functional kinds to justify inferences between specific expressions of material culture and modern cognition. On the other hand, the essentialist approach to BM posits a sort of metaphysical definition for behaviors that intrinsically count as modern, independent from their cognitive realization. This approach seems to consider BM as a natural kind according to the sixth of the criteria reported in Section 4.1. Incidentally, such a criterion defines natural kinds as essences, by referring to intrinsic properties of artifacts. According to this perspective, it follows that the broadly recognized quintessentially modern behavior, namely symbolism, ought to be considered as modern *in se*, without any concern for its causal connection to modern cognitive architectures. This position would lead therefore to the paradox that behaviors considered essentially modern could be in principle realized also by primitive mental architectures. A disconnect between instances of behavior and the specific mental mechanisms underlying them impedes to consider the resulting research project as a form of cognitive archaeology. Rather, this approach configures itself as philosophical anthropology dealing with the metaphysics of behavioral essences. At present, the onus of providing convincing theories for the existence of such modern behavioral "essences" rests with supporters of the essentialist approach.

However, both list- and essence-based approaches share an important aspect. In either case, the improper use of BM as a natural or functional kind has led to problematic inferences between artifacts and minds. Such inferences are plagued by deep epistemological problems, which I have extensively discussed in Section 3. The use of BM as an epistemic tool is incommensurable with the analytic categories of holistic mapping and logically circular. Furthermore, it is incompatible with the tenets of material engagement and it fosters neurocentric and deterministic positions. Epistemological incompatibility, in turn, leads classic BM approaches to produce incommensurable theories in cognitive archaeology. Different theories, if assembled with incommensurable methods, can lead to radically different explanations of the same artifacts in the record. This contradiction, however, could originate from their incommensurable epistemic premises, rather than from their theoretical contents (Garofoli and Haidle, 2014). Incommensurability is pernicious for cognitive archaeology since it produces inconclusive debates and impedes progress in this discipline.

Despite all this, an ultimate attempt might be provided in order to save the notion of BM. Namely, it might be argued that BM still deserves to be maintained because it eases scientific communication among scholars. However, at this point, I hope to have sufficiently shown that BM is at best irrelevant for cognitive archaeology and at worst detrimental. Given the problems of incommensurability, circularity and determinism that affect BM and the many risks we have to consider in maintaining this notion, any further use of BM invites caution.

6. Conclusions

In this paper I have argued that BM does not count as a natural kind and therefore cannot be the target of reliable scientific analysis. At the same time, its role as a functional kind is irrelevant for cognitive archaeology, because BM stems as a negligible byproduct of the holistic mapping method and does not have an explanatory function. Traditional approaches to BM have treated this notion in terms of arbitrary lists, unwarranted functional kinds or metaphysical essences that are incommensurable to the scope or methods of cognitive archaeology. Incommensurability is harmful for cognitive archaeology and, looking back at the history of the discipline, it is reasonable to expect that the costs of maintaining BM disproportionately outweigh any benefits. In consequence, I recommend eliminating BM from the cognitive archaeology vocabulary.

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A.4

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Do early body ornaments prove cognitive modernity? A critical analysis from situated cognition

Duilio Garofoli

Abstract The documented appearance of body ornaments in the archaeological record of early anatomically modern human and late Neanderthal populations has been claimed to be proof of symbolism and cognitive modernity. Recently, Henshilwood and Dubreuil (*Current Anthropology* 52:361–400, 2011) have supported this stance by arguing that the use of beads and body painting implies the presence of properties typical of modern cognition: high-level theory of mind and awareness of abstract social standards. In this paper I shall disagree with this position. For the purposes of the argument, body ornaments are divided in three categories: aesthetic, indexical and fully-symbolic, on the basis of the necessary and sufficient conditions to construct meaning for each category. As previously acknowledged by a number of authors, I will argue that the abilities considered by Henshilwood & Dubreuil necessarily apply only to fully symbolic ornaments and they do not extend to the aesthetic and indexical categories. Indeed, a series of situated strategies can be sufficient to process non-symbolic categories of ornaments, through their phases of initiation, understanding and maintenance. Since these strategies could be implemented also by non-modern cognitive architectures, it is concluded that early body ornaments are currently unable to support cognitive equivalence between primitive and modern human populations.

Keywords Cognitive archaeology · Enactivism · Early body ornaments · Mindreading

1 Introduction

A key topic in cognitive archaeology (CA) concerns the emergence of behavioural modernity in the Middle-Upper Palaeolithic transition and its relationship with human cognition. According to the "revolution" model (Klein 2009; Mellars 2006; see Nowell 2010 for review), the European Upper Palaeolithic shows evidence of technological innovations that has no precedent in the African Middle Stone Age. Musical

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instruments, ivory figurines, therianthropy, parietal art, symbolic artefacts and blade stone tools (see Bar-Yosef 2002, pp. 365–8 for review) have been used to support the existence of a technological leap in the archaeological record of modern humans.

In the context of the debate concerning the emergence of behavioural modernity, some scholars (Klein 2000, 2008; Coolidge and Wynn 2005, 2007; Wynn and Coolidge 2009) have argued that a discrete mutation in brain networks is necessary to account for this technological leap. According to Richard Klein, this mutation augmented some aspects of mental architecture, leading to the emergence of an "enhanced phenotype" at ca 60 kya, which rapidly replaced unenhanced humans and allowed the former to develop technological advancements.

However, many archaeologists contest the idea that the Upper Palaeolithic transition marks a discrete leap in technological complexity. They point out that the African Middle Stone Age artefactual record indicates the likelihood of behavioural practices that are commonly individuated in the Upper Palaeolithic material culture. In particular, they claim that the emergence of artefacts interpreted as body ornaments, like beads and ochre pigments[1], in some African (d'Errico et al. 2005, 2008, 2009; d'Errico and Vanhaeren 2007; Bouzouggar et al. 2007; Marean et al. 2007) and Middle Eastern (Bar-Yosef Mayer et al. 2009; Vanhaeren et al. 2006) sites, far predates Klein's threshold of 60 kya.

These scholars defined a concept of "behavioural modernity" based upon a prototypical set of practices that are usually associated with modern humans (McBrearty and Brooks 2000; d'Errico 2003; Bar-Yosef 2002). In particular, they claimed that the use of body ornaments is grounded on and explicitly marks the presence of symbolic behaviour in these populations. As a consequence of this premise, they considered body ornaments as proof of behavioural modernity and inferred that these early modern human populations shared the same cognitive bases with fully modern ones. Contra Klein, these biological capabilities were not the product of a discrete mutation in the architecture of the brain at 60 kya, but arrived with the speciation of modern humans much earlier in the African Middle Stone Age (Nowell 2010, p. 445).

In addition, recent evidence links late Neanderthal populations in Europe to the use of body ornaments (Zilhão et al. 2010; Caron et al. 2011; Peresani et al. 2011). This evidence led to the claim that behavioural modernity is neither constrained by biology, nor necessarily connected with modern anatomy. On this argument, even Neanderthals were considered capable of innovating and using symbols. Extreme proponents of the "cultural school" have therefore claimed that the same cognitive/biological bases were present in human populations from the Middle Pleistocene onwards (d'Errico and Stringer 2011) and that modern and archaic populations were cognitively equivalent (Harrold 2009; Zilhão 2011).

However, it is of considerable significance that arguments about cognitive equivalence are often grounded on a set of a priori assumptions that lack a logical analysis of the properties of artefacts (see Garofoli and Haidle 2014; Botha 2010; Barnard 2010a

[1] Ochre has been associated with several uses in the archaeological literature. Henshilwood and Dubreuil (2011) report for example the use of this mineral for hafting procedures (e.g. Wadley 2005; Wadley et al. 2009), healing practices (Velo 1984) and the production of engraved objects (Henshilwood et al. 2002, 2009). For the purposes of the argument, in this paper I have focused on the explanation of ochre as a pigment for body painting (e.g. Watts 1999, 2002, 2009). This clearly does not rule out the other potential explanations, nor the fact that ochre could have been used for multiple purposes (Lombard 2007).

for discussion about related epistemological issues in CA). Indeed, body ornaments have been commonly included into a broad category of symbolism, which in turn has been associated with a notion of behavioural modernity and axiomatically used to argue for cognitive modernity (Fig. 1).

This can lead to situations where the results of the analysis are in practice decided in advance (Langbroek 2012; Garofoli 2013). If, indeed, all body ornaments are symbols and symbols by definition require modern cognition to be handled, it follows automatically that any hominin able to produce these ornaments is cognitively modern (Garofoli and Haidle 2014, p. 28). Such inferences are unwarranted a priori and must be supported by a logic of necessity and sufficiency. If the ornaments-symbols relation is demonstrated to be unnecessary, for example, then inferences that follow downstream in their turn are unnecessary.

A more epistemologically coherent debate that tackles these problems has recently emerged in the context of Henshilwood and Dubreuil's (2011, H&D henceforth) work on the South African Still Bay and Howieson's Poort techno-complexes. These authors analysed the use of body ornaments by describing the relationship between agents, meaning and communicative targets and then they mapped this resulting behavioural system to properties of cognition of these early modern human populations, as well as properties of neural architectures.

As a result of this a posteriori analysis, H&D argued that aesthetic ornaments like beads and ochre are imbued by users with the meaning of *coolness*. "Being cool" is considered a shared abstract property that shows one's standing in the public space and game of relationships (p. 390). In this way, a person wears ornaments because she knows not only that other social members can see her wearing the artefacts, but also because she is aware of *how* they see her. In consequence, at a socio-cognitive level, H&D argued that these artefacts require full-blown theory of mind, which is generally considered to be the ability to explain the observable behaviour of other people by making inferences about what they are thinking (Baron-Cohen 2001; Apperly 2011). Meaning of early body ornaments is therefore constructed as a form of arbitrary and conventional connection between a physical artefact and a socially shared representation, here the concept of COOLNESS[2]. On these grounds, H&D argued that the arbitrary connection between COOLNESS and aesthetic body ornaments satisfies a semiotic definition of symbol (e.g. Sebeok 1994, p. 11). Their conception of symbolism comes in association with a set of costly cognitive strategies, which are assumed to support the need for abstract shared standards in making sense of these ornaments. In turn, these cognitive processes plausibly entail the presence of an underlying cognitive architecture that is substantially similar to that of contemporary humans. By virtue of their symbolic approach, H&D conclude that early body ornaments like beads and ochre pigments necessarily imply cognitive capabilities that are comparable to those of Upper Palaeolithic populations[3].

However, some authors (Rossano 2010, 2011; Coolidge and Wynn 2011; Gärdenfors 2011) collectively contended that beads and body painting do not necessarily belong to

[2] In this paper I have used caps to name concepts.

[3] More precisely, they claim that there are no significant differences between the higher cognitive properties of early body ornament makers and those of contemporary human populations (Henshilwood and Dubreuil 2011, p. 378–9).

Fig. 1 Linear chain of inferences used to derive cognitive modernity from the presence of body ornaments in the archaeological record

the category of symbolism. Drawing upon the semiotic framework of Peirce (e.g. Peirce 1998, 1931–36, 1958; Hoopes 1991; Preucel 2007, chapters 3–4), they argued that use of these ornaments could be indexical rather than symbolic.

This form of argument remains preliminary in several respects. One problematic aspect lies in the fact that non-symbolic explanations of early body ornaments are still underdeveloped. The debate requires augmentation with a more coherent framework for specifying how the non-symbolic categories of aesthetic and indexical artefacts are imbued with meaning and cognitively processed. To concretize this, when Coolidge and Wynn (2011) propose that beads ought to be explained as indexes, they do not refer to any specific logic of connection between artefacts and meaning. Besides the almost tautological statements that indexes indicate their meaning and symbols stand for it, deeper logical foundations do exist. They ought to be taken into account and clearly spelled out. Furthermore, since body adornment arises in a social context, it is vital to examine its course of development, from its behavioural origins to a fully established cultural practice. Without such an analysis, symbolic explanations could be inappropriately invoked when simpler non-symbolic alternatives have not been thoroughly explored and specified.

2 Aims of the paper

The analysis presented here will demonstrate that beads and ochre pigments do not need to be explained as necessarily symbolic artefacts. While ascribing the abstract concept of COOLNESS to an artefact and its social sharing is one possible strategy for making sense of early body ornaments, it is not the only one.

More minimalistic cognitive strategies, mostly grounded on situated cognition and long-term material engagement (Malafouris 2004, 2011; Malafouris and Renfrew 2009) could be sufficient to explain early body ornaments. Contrary to H&D's argument, this would allow us to explain beads and ochre pigments without recourse to full-blown mindreading, explicit awareness/manipulation of abstract concepts and shared social standards. If early body ornaments could be considered as non-symbols and processed without requiring properties typically ascribed to modern cognition, the presence of these artefacts in the archaeological record would not then automatically prove cognitive modernity/equivalence. I shall conclude by briefly discussing the wider implications of the potential link between early use of body ornaments and cognitive architectures that are less advanced than fully modern ones.

3 Analytic tools

In this attempt to eliminate the conditions of necessity that, in H&D's proposal, connect beads and ochre pigments to abstract shared concepts, I will examine the same categories of ornaments discussed in their work, namely aesthetic, indexical and symbolic ones. I shall provide a multidimensional analysis that integrates the logic of meaning/artefact relation with a motivational and cognitive perspective. This will include a chronological dimension that describes body adornment as an evolving cultural practice. The particular dimensions of enquiry will be illustrated in the following sections.

In Section 4 I shall integrate these dimensions in order to identify a set of necessary and sufficient properties defining each category of body ornaments. These basic categories will be ultimately compared with the requirements for body adornment advanced by H&D. I will attempt to show that while these requirements apply only to the category of full-symbolism, beads and ochre pigments can be explained by means of non-symbolic categories, namely aesthetic and indexical ornaments. This will remove the conditions of necessity linking ornaments to abstract shared standards.

3.1 Semiotics

The first dimension of this analysis concerns the logic of relationships that hold among artefacts, their makers, their meaning and their communicative targets. In the context of the debate about H&D's argument some authors have discussed this aspect by drawing from the semiotic perspective formulated by Charles Sanders Peirce (1931–36, 1958). According to this approach, a sign is any physical form that is connected to an object, event, feeling, etc., known as a referent, by virtue of an imagined or concrete link (Sebeok 1994). Signs consist of three inter-related components: a sign, an object, and an interpretant (Atkin 2013). A sign could be intended as the signifier (e.g. smoke signifies the presence of fire), while the object is to be intended as whatever is signified (e.g. the fire signified by the smoke). The interpretant can be defined as the understanding that we have of the sign/object relation. In this way, Peircean conception implies that the meaning of a sign emerges from the interpretation that users make of it. Peirce introduced a basic distinction between categories of signs, which is grounded on the nature of the logical relations among the elements of his triadic system. The three classes of signs are icons, indexes and symbols.

However, this classification is only superficial (Deacon 1976). Each category can be subdivided into a series of component classes that specify different kinds of relations among objects, signs and interpretants. A deeper analytic approach involving more precise categories has clear advantages. It would allow more specific relations between signs and objects to be highlighted, which can become the target of cognitive processes while producing interpretants. However, a fully detailed account of these analytic categories is beyond the scope of this paper. The key problematic aspect with the debate around H&D's argument concerns the lack of clear specification in the logic of ornaments-meaning relationship within the basic Peircean triad. This is particularly evident in the case of non-symbolic semiotic categories. As a consequence, I will focus on this rather basic level of semiotic analysis. It is worth noting that the three categories of ornaments I shall take into account, namely aesthetic, indexical and fully symbolic ones, slightly differ from the Peircean categories in the iconic/aesthetic distinction, whose correspondence might be debated.

3.2 Motivations and social grounding

A fundamental aspect of the debate about early body ornaments concerns the Peircean concept of *interpretant*. This specifies how the sign/object relation is constructed and understood by its maker, as well as by her communicative targets, that is those intended as the recipients of the communicative act of body adornment. At the same time, since body ornaments are produced to express meaning for someone, it is necessary to establish why this purpose was considered important. In other words, we need to know not only *how* meaning is ascribed to an artefact, but *why* it was so ascribed. As a consequence, we require a motivational component to be integrated into the logical relationships that connect ornaments to their meaning. For a full understanding of each category of body ornaments it is therefore necessary to situate the semiotic and motivational components within a social context. This dimension is represented by the following *grounding phases*:

1) **Initiation**: the process through which a body adornment practice is created and recognized by its maker as worth being stably maintained.
2) **Understanding**: when communicative targets acknowledge what the practice means and why it is valuable to reproduce it.
3) **Maintenance**: the process underlying long-term propagation of a body adornment practice.

3.3 Situated cognition

The current argument adds a third, cognitive, dimension to augment the semiotic and motivational ones. The relations among entities and motivations for body adornment involved in the three grounding phases will be examined in terms of those necessary and sufficient cognitive processes required to process them. In doing this, I shall integrate these three dimensions into a unique framework and compare the results of this analysis with the conclusions advanced by H&D. The critical point of this paper is that the aesthetic and indexical categories of use do not necessarily require the most advanced cognitive processes. To explore this alternative explanation, I will discuss how a set of situated strategies can support the logical relations and motivations involved in the three phases of grounding for non-symbolic categories of ornaments.

3.4 Mindreading vs Enactivism

As noted earlier, a crucial aspect of H&D's analysis is the necessary involvement of "full-blown mindreading". This entails the capability of thinkers to infer other people's mental states and use them to predict or explain their behaviour (Baron-Cohen 2001; Apperly 2011 pp. 5–7). On this view, predicting behaviour implies ascribing to others a set of interrelated beliefs and desires that plausibly justify the predicted behavioural outcome. In contrast, explaining observed behaviour entails inferring a network of beliefs-desires that is likely causing that behaviour. Both these cases require inference "at the best explanation" (i.e. abduction), where the context (e.g. social scripts and norms) is used to constrain the plausibility of the connection between mental states and behaviour (Apperly 2011, p. 128–32).

Two different approaches have been proposed to explain this phenomenon, each of which has several variants. According to Theory-Theory (TT) models (Fodor 1992; Leslie et al. 2005; Gopnik and Meltzoff 1997; Godfrey-Smith 2005), we understand other people by constructing a theory of how mental states (i.e. beliefs, desires, thoughts, etc.) are related to behaviour, as well as inter-related. A second school of thought, namely Simulation-Theory (ST), argues instead that our own mind can be used as a model to infer mental states and their relation to actions (Goldman 1989; Gordon 1986, 2008).

Despite the differences between TT and ST, both proposals share the modality they adopt to explain how people understand the behaviour of others. Indeed, they claim we do that in a *mentalistic* way, meaning that we get access to and we represent other people's mental states *as such*. When applied to the case of early body ornaments, this means the concept of COOLNESS is not only explicitly attached to the beads by their makers. It is also individuated in the minds of the communicative targets in the form of a mental state. Besides the exact implemented modality of mindreading (i.e. TT or ST), the maker initiates the body adornment practice because she predicts that other people might ascribe the same concept of COOLNESS to the ornaments. In this way, she organizes her behaviour on the basis of what she expects other people would think. These targets understand the intention of the maker as her desire to be cool. They acknowledge she wants to pursue this goal by ascribing a concept, COOLNESS, to an artefact. They also understand that the maker wants to do that because she believes they will share with her the same beliefs about COOLNESS. This practice ultimately propagates and it is maintained as a consequence of the continual mutual and reciprocal awareness of what is within each other's minds. This creates what H&D define as an abstract shared social standard, which leads to awareness of position in the game of reputation. Taken together, these steps specify the three grounding phases for early body ornament practice, and explain the practice by referring to mentalistic strategies. The computational costs involved in these strategies, be they Theory or Simulation based, would appear to be inherently rather demanding. As such, it is not surprising that so called full-blown mindreading (also known as high-level mindreading or level-2 perspective taking) is considered to have required a significant leap in both developmental and comparative psychology. Many experiments conducted in developmental psychology look for the minimal presence of full-blown theory of mind in infants, as if this capability represented a step towards the structure of a mature mind (see Apperly 2011 for a theory of the division between low- and high-level mindreading processes in humans). A similar argument holds for comparative psychology, where full-blown theory of mind is used to highlight the difference between humans and apes (Penn et al. 2008). Using full-blown mindreading as a *signature trait* of a modern cognitive architecture seems to be a quite reasonable (and shared) approach.

However, I shall argue here that non-symbolic ornaments can be accounted for in each of the grounding phases, without necessarily requiring such mentalistic strategies. To this end, I shall draw on the most radical approach to social understanding, namely enactivism (Hutto 2004, 2008, 2011; Gallagher 2008; Gallagher and Zahavi 2008; Gallagher and Hutto 2008; Reddy and Morris 2004; Fuchs and De Jaegher 2009; de Jaegher and Di Paolo 2007; see Malafouris 2007, 2010, for a first implementation of this approach in CA). This, however, does not preclude similar arguments from cognitivist perspectives, such as Naive Theory of Mind (Bogdan 2009), registration of encounters (Apperly and Butterfill 2009; Butterfill and Apperly 2013) or Early Mindreading System (Nichols and Stich 2003).

The radical enactive approach to social understanding recruits a form of direct perception (Gibson 1979; Chemero 2009; Hutto and Myin 2013) to explain the way we often make sense of others. While the mentalistic approach holds that we can understand other people intentions and actions by getting access to the contents of their minds and representing their mental states as such, enactivism provides a non-mentalistic approach to reach the same goal. This approach implies that we can understand others by looking directly at their actions, which immediately reveals their meaning, without necessarily getting access to mental states to justify the action. In Shaun Gallagher's words:

> *Seeing the actions and expressive movements of the other person in the context of the surrounding world, one already sees their meaning; no inference to a hidden set of mental states (beliefs, desires, etc.) is necessary.* (Gallagher 2008, p. 542)

This form of social direct perception differs from behaviourism in that we do not simply grasp a chain of stimuli-responses. By looking at the other person's actions and at the context where they are situated, we grasp the intentionality behind them (what are the actions for), without being aware of the intensionality (with s), which defines the mental states behind the action itself (Hutto 2011). For example, anger can be directly perceived as the set of embodied actions and expressions an angry person displays. What the observer sees when it faces this behaviour *is* anger (Gallagher 2008). The context where an embodied expression of anger takes place reveals directly the situation and the object to which anger is directed. At the same time, the context itself reveals the cause that produced the angry reaction in the subject. In this way, causes, reactions and targets are all tightly coupled and perceived together. No network of causal relations among mental states of the other person, emotional states and actions must be explicitly cognized to understand meaning.

How can we come to acquire an understanding of the meaning of action through direct perception? Several authors, albeit with different approaches, have offered an answer to this question by stressing the importance of developmental context. The common ground for this argument is that cultural norms and scripts shape the context and scaffold the understandings of other people, without involving mindreading. In this way, social meaning becomes gradually evident to human children through long-term enculturation in a "community of minds" (Nelson 1996, 2005) or similarly by means of a set of culturally embedded practices like narratives (Hutto 2008, 2009; Gallagher 2003; Gallagher and Hutto 2008; see de Bruin and de Haan 2012, for review). In this way, the background helps make sense of an action by constraining the plausibility of its meaning (see also Apperly 2011, p. 160). However, it does so by shaping meaning for the "directedness" of actions towards a target, instead of providing a set of rules that are then used as a part of abductive reasoning.

The enactive approach to social understanding is primarily grounded on phenomenological arguments. While modern humans are in principle capable of understanding others by reasoning in mentalistic terms, enactivists argue that most of our social understanding intuitively does not involve intricate metacognitive reasoning. Conversely, direct perception is primary in that it emerges earlier than mindreading in the course of development and it stands as the default model of social cognition even into adult life.

In this paper, I shall examine the idea that non-symbolic body adornment could be initiated, understood and maintained by means of these enactive strategies.

3.5 Situated concepts

An important aspect of H&D's proposal lies in the assumption that early body ornaments require associating artefacts with an abstract concept of COOLNESS, which is treated as a shared social standard. In order to ground a critique of this argument, a closer examination of the nature of concepts is required.

The notion of concept, like that of sign, is not unitary. Three classes of concepts are distinguished in the classic cognitive science domain: prototypes, exemplars and theories (see Murphy 2002 for review). According to Edouard Machery (2009), these constructs ought to be treated as distinct entities (i.e. the heterogeneity hypothesis), since they are acquired through different processes and independently adopted across various cognitive tasks. More in detail, a specific categorization process may exist for each kind of concept introduced earlier. Prototypes and exemplars, however, share a common aspect. Despite differences in the kind of information they are based on (i.e. prototypes are bodies of statistical knowledge, whereas exemplars are single instances of an entity), these two kinds of concepts rely on a categorization mechanism implemented by matching entities to a standard representation and evaluating their similarity.

In contrast, theories are bodies of causal, functional, generic, and nomological knowledge about entities. They are constituted by networks of causal relations that explain "why things happen" or why something belongs to a specific category (e.g. X is a dog because it barks). A model for categorization based on theoretical concepts (Rehder 2007) contends that an object belongs to a category "A" if we can assume its properties could have been generated by the causal laws that define "A". This model of categorization is distinctly different from those based on prototypes and exemplars. It does not involve computing the similarity between a representation and a target. Instead, it consists in knowing how likely it is that the causal laws which define a candidate category can produce the features observed in a target object. Causal knowledge is therefore employed to make predictions about the most likely configuration of properties that define category members. Consistent with the position of Murphy and Medin (1985), this form of categorization seems to involve reasoning to the best explanation. Indeed, abduction is required when we compare expected properties within a candidate category with actual features shown by the target entity.

I argue that COOLNESS should be considered as a theory. Given its status as an abstract social standard, I find it *prima facie* counterintuitive to conceive of COOLNESS as a prototype or an exemplar. On the contrary, COOLNESS seems to fit particularly well into a nomological framework that binds together a set of concepts, embedding concrete events (e.g. the reaction of people to an individual showing certain features), as well as abstract ones (e.g. CHARISMA, APPRECIATION, etc.). In addition, it is also possible that COOLNESS contains further embedded theories. It appears therefore quite plausible to consider COOLNESS as assembled through an introspective reasoning process, if not uniquely acquired through linguistic definition (Piccinini 2011).

Importantly, theoretical concepts are not necessary for producing early body ornaments, especially if we consider that in H&D's proposal the cognitive costs of this requirement disproportionally increase when theoretical concepts must be socially shared through mindreading.

Given the substantial differences existing between kinds of concepts (Machery 2009), primarily focused in the opposition between similarity matching and abduction, it could even be possible to advance a counterargument from a cognitivist perspective. If the conceptual knowledge involved in the production of early body ornaments could be explained in terms of prototypes and exemplars, then this would already suffice to rule out theories from these practices, leaving room to further debate on cognitive architectural requirements.

However, in this case I will be consistent with my core commitments by adopting situated concepts (Barsalou 1999, 2008, 2009; Barsalou et al. 2003; Prinz 2002, 2005; Gallese and Lakoff 2005) as a minimalistic strategy for making sense of ornaments. Situated concepts contrast with those approaches that assume that cognitive processes implement representations that differ from memories of the original sensorimotor states (Barsalou et al. 2003). According to classic models, sensorimotor representations of entities are formed within the neural system, but are then converted into amodal structures (i.e. prototypes, exemplars and theories), which could take, for example, the form of a list of features or a semantic network.

In contrast, proponents of situated concepts argue that conceptual knowledge is encoded in perceptual and motor representational formats. In this way, concepts are constructed by tokening some perceptual representations, which are stored in long-term memory, a process that results in "perceptual symbols" (Barsalou 1999; Barsalou et al. 2003). Cognitive processes involve manipulating perceptual symbols that are effectively re-enacted through a process of simulation (Barsalou 1999, p. 578). Concerning categorization, simulation models propose the following (Barsalou 1999, p. 587): a) perceiving a target entity enacts a simulator for a category stored in long-term memory, b) the simulator provides a sensorimotor simulation, which is compared with the perceived target, c) if the simulation is satisfactory enough to include the entity within the category, then the entity belongs to it, d) otherwise, the entity does not belong to the same category and other simulations are necessary for categorizing it. The example of simulation-based categorization shows that cognitive processes work on a body of information that shares the same sensorimotor nature of the perceived entities that must be categorized.

Simulation models are well suited to explain high imageability concepts, but they traditionally encounter problems in proposing satisfactory explanations of abstract concepts. In this way, some scholars (Dove 2009; Machery 2009) argued in favour of representational pluralism, where situated concepts coexist with amodal ones.

Having clear and precise distinctions between kinds of concepts is relevant to the early body ornaments problem. It is plausible to propose that there are different cognitive costs in processing situated concepts and abduction-based theories. It then becomes worth considering whether conceptual knowledge involved in the three grounding phases of early body ornament practices requires theoretical concepts or just situated ones. If the latter kind suffices in processing non-symbols, then this would raise doubts about the validity of the association between early ornaments and modern cognition. For it is not a priori given that a cognitive system capable of comparing perceived entities with situated simulations is also capable of constructing networks of causal inferences and use them to categorize aspects of reality.

4 Development

4.1 Aesthetic ornaments

I define an aesthetic ornament as an artefact that acquires relevance in a social group because it elicits positive emotional reactions among its users. I shall now examine the three grounding phases in the following thought experiment. Let us think of an imaginary member of an ancient social band, who for the purposes of this experiment, we will refer to as Sally.

4.2 Initiation

One day Sally finds a gold nugget in a river. She is immediately attracted by its shiny appearance and experiences a positive feeling about it. Sally returns to her band with the nugget in her open hand. Soon she is surrounded by conspecifics who are also interested in its appearance. At this point, we can think of conspecific agents being coupled in a system exhibiting the property of resonance. Meaning emerges within the interactions among Sally's body, her arm holding the stone and the embodied reactions of her conspecifics. They look amazed at the unusual appearance of the nugget she holds and then they directly perceive a new relationship of "Sally holding nugget". This relationship itself acquires some form of special significance to their eyes. Her body is now extended by the presence of the nugget. With it on display, Sally notices that the attention of her conspecifics is directed to her own arm holding the stone. She also grasps that their embodied reactions are directed at and caused by her disposition. Since the embodied reactions and vocalisations directly show their emotional content (they *are* amazement), Sally resonates to their positive reactions and herself experiences a positive reaction to their responses. Over time, this state persists while the nugget is in her possession, reduces when she puts it aside and recurs when she picks it up again. We need to suppose no more than straightforward learning mechanisms for her to establish that material and/or adhesives used in hafting could enable the nugget to become "attached to her body" without holding it with one hand and thus propagate her positive embodied reactions. Sally, therefore, *initiates* the practice of adorning her body with gold.

4.3 Understanding

Up to this point, we do not need to argue that Sally has represented beliefs in the mind of her conspecific band members. She does not have to create a theoretical network of causal inferences that define a concept of COOLNESS and explicitly ascribe it to the artefact. Nor do we have to suppose she has organized her practice on the basis of an identical concept of COOLNESS identified in other people minds. In other words, Sally has no need to justify the embodied reactions she perceives by connecting them to a set of beliefs or thoughts other people hold. She can directly perceive the relevance of the nugget by connecting her hand-holding of the stone to the sights and sounds of the embodied reactions of self and the others.

In the *understanding* phase people experience this new extended version of Sally wearing the gold nugget as a bead. We can then consider what the ornament signifies to the eyes of the observing conspecifics and how it acquires meaning. As mentioned before, they can directly perceive Sally's new extended aspect and attach an aesthetic value to that. In semiotic terms, they do not have to build a theory of COOLNESS and to ascribe it to the object. To the eyes of the observer the artefact does not stand for it, meaning that it does not replace the concept of COOLNESS.

I contend that the nugget needs not even indicate COOLNESS. For no theoretical concept of COOLNESS (no causal network of inferences) needs to be associated to the object in order to understand its relevance or significance. If this is true, it follows that no awareness of COOLNESS in Sally's mind is required and no abstract shared knowledge is necessarily involved in understanding this practice. This leaves open the issue of how to classify this practice in semiotic terms, since there would be no more clear connection between sign (the gold nugget) and object (COOLNESS). A first move to overcome this problem, for example, could be to claim ornaments have no meaning (e.g. Coolidge and Wynn 2011). This, however, would leave us with the problem of explaining how a person can understand what a body adornment practice is, without understanding what it means.

One way to address this problem would be to assume that the gold nugget is iconic (as proposed by Rossano 2011). According to a classic semiotic definition (Sebeok 1994, chapter 6), icons are signs interpreted as standing for their objects by virtue of some shared quality. What must be understood in making sense of these signs is the perceptual similarity between signs and objects. For example, the icon of a phone that represents a phone booth on a topographic map shares common traits with the object (telephone) which is to be found there. This allows us to conclude that there is indeed a telephone in the point reported by the icon. With respect to the nugget example, it could be argued that the nugget can iconically mean that the body of Sally is made of gold. However, since this explanation could appear weak when applied to other kinds of aesthetic ornaments not made of gold, I suggest that a broader definition of iconicity should be adopted. This would not imply similarity between sign and object. In this loose sense, iconicity should be intended as the fact that the ornament produces a new icon of Sally's body: *extended Sally*. This new icon is coupled with emotional reaction internal to the subject and at the same time with the perceived embodied reactions of other surrounding people as directed towards extended Sally. Extended Sally becomes deeply embedded in long-term memory as a situated example of an interest attracting, emotion invoking, *cool* individual.

4.4 Maintenance

This argument is far from saying a theory of COOLNESS must be attached to the gold nugget in order to understand it. The understanding of the bead elicits the state of need or even desire to have the same embodied reactions directed towards the subject and imitation leads to the reproduction of the practice. Using gold as body ornament propagates and a generic model of a "cool" individual is gradually constructed from the primitive case of Sally. The practice propagates over conspecifics and becomes part of a series of social norms and goes to shape the context in which successive generations grow up. Children's development is situated in an environment where they can gradually encounter and become familiar with extended individuals wearing ornaments. The social architecture surrounding the children can act as scaffolding to allow them making sense of extended individuals, without necessarily attaching theoretical concepts to ornaments and getting access to these theories in the minds of the others. The practice would therefore become *maintained*.

4.5 Indexical ornaments

In Peircean terms, indexes are signs interpreted by virtue of some brute, existential fact that causally connect them with their objects (Sebeok 1994, chapter 5). A weathervane for example has physical properties that allow it to align to the direction of wind. When we form an interpretant, we thus understand that the position of the weathervane indicates the direction of the wind. Indexical body ornaments follow the same standard. Gold nuggets are rare and difficult to find. When Sally wears a shiny necklace with several gold nuggets she appears in the eye of any observing conspecifics to be capable of providing and showing off such a rare material. Gold nuggets therefore become indexical of Sally's capability of finding rare and desirable items by virtue of an existing natural law that characterizes them (i.e. their rarity).

The three grounding phases for indexical body adornment practices create problems similar to those for aesthetic artefacts. Most importantly, these problems again deal with the formation of an interpretant, namely the way the causal relationship between sign and object is understood by users. At the same time, they regard the necessity of implementing mind-reading strategies that allow the indexical/causal relationship to be seen as a mental state in other people's minds and to regulate the action accordingly. Against this background, the discussion in the previous section generally also applies to the three grounding phases of indexical artefacts. The main difference between the aesthetic category and the indexical one lies in the properties that allow them to become relevant. While aesthetic ornaments become relevant to the eye of the observer through an emotional mechanism, indexical ornaments rely on causal connection. However, the basic combination of enactive strategies and long-time interaction with extended phenotypes generally explains this category of ornaments without requiring mentalistic strategies or theoretical concepts.

For a concrete example, let's replace Sally with Adam, a hunter who, after killing a wild beast, subsequently processes and wears its skin as clothing. This body ornament not only works as a memento of the killing. It is also indexical of the fact that the hunter is strong/brave enough to kill a beast and advertises this trait to other members of the band. Let us suppose that while out hunting with others, Adam is attacked by a fierce wild beast. After fighting alone with that dangerous animal, he dodges the beast charge and stabs it with his own weapon, killing it in one single blow. The other hunters immediately surround Adam looking at him with visual and vocal expressions of relief or pleasure. As with the thought experiment applied to Sally, Adam directly perceives the coupled system given by the interaction between him standing in front of the dead animal and the embodied reactions of admiration displayed by others. This could motivate him to keep part of that prey with him, in order to perpetuate the set of reactions he experienced. He, like Sally, initiates a practice, in this case the wearing of animal skin, becoming therefore *extended Adam*.

The other people look at Adam with surprise and admiration, because from what they know from their own past experiences, they are indeed aware that those animals are very dangerous and hard to catch. The scene they observed proves Adam was capable of killing that prey: hence Adam is strong. When they look at extended Adam wearing the skin they are in a position to reconstruct aspects of the scene they have experienced in the past. Adam's extended phenotype becomes a situated instantiation of "beast slayer". The coupled system that emerges between this new body icon and the embodied reactions of conspecifics represents a motivation for imitating the practice and leads to the formation of stereotypical extended phenotypes and social scripts.

In each of the three phases no inference to the other people's mental states is necessary to support this practice. All that is needed for the processing of indexes is grasping the causal relation between the skin of the animal and the abilities of the hunter who managed to procure it. This does not require the explicit awareness of conceptual theories that are attached to artefacts and then individuated in the mind of the others. For example, to understand what extended Adam means, it is not necessary to create a network of inferences that define STRENGTH and to imbue the animal skin with this concept. It is sufficient to look at the animal skin on the body of the hunter to reconstruct the episode of Adam killing the beast. The body-artefact complex (i.e. extended Adam) allows the other individuals to be aware Adam is strong without explicitly holding a theory of STRENGTH to justify the meaning of the ornament. In the maintenance phase, when extended Adam has already become a model of the brave hunter, children are in direct contact with these social scripts and gradually learn to appreciate the correlation between animal-derived body ornaments and hunting capabilities, as well as they learn to understand that between grey beards and adulthood.

4.6 Full-Symbols

Symbols imply that the relationship between objects and signs is arbitrary and conventional. They are constructed by establishing a connection between object and sign that exists only in the minds of society members and it is not based on any physical resemblance or causal law. While in indexical signs a physical law that connects objects and signs must be recognized when creating an interpretant, for symbols the connection is created by virtue of a convention. Differently from icons and indexes, whose use can *become* conventional, for symbols the conventional aspects is therefore *constitutive* of the same triadic relation between elements (Peirce 1931–36)[4]. In addition, according to the anthropologist and neuroscientist Terrence Deacon, a sign acquires the status of full symbol only if it exists within a system of symbols (Deacon 1997). What differentiates the use of symbols in apes like Kanzi and Washoe from the human use of symbols is the fact that humans not only are able to associate a symbol to a non-causally or physically limited meaning. Differently from apes, indeed, humans can also understand the relationship between the symbol and other symbols, so that a second order relational understanding is introduced (Perinat 2007; Penn et al. 2008).

[4] See for example paragraphs 2.249, 2.292, 2.297, 2.299, 2.307

In terms of semiotic structure, religious or ideological symbols provide clear examples of a fully conventional attribution of meaning to material artefacts. In these cases, a set of values and their relations are explicitly cognized and ascribed to artefacts in a conventional way. In the case of political party symbols, for instance, meaning is constructed by imbuing these signs with abstract values, like social justice, liberty, egalitarianism, authority, abolition of the state, etc… These values are definitional, theoretical, introspective and clearly leave room for the possibility that they need to be understood in terms of additional abstract networks of relations that specify each of them. The initiation phase implies these ornaments can be imbued with meaning by assuming that other people would acknowledge the same values and grasp the arbitrary connection with the artefact. In terms of social cognition, this implies that the initiator must expect their communicative targets to acquire the same propositional beliefs she holds. Then, she should expect that they would ascribe these beliefs to artefacts by sharing the same arbitrary connection she has in mind.

Initially, communicative targets have no direct access to the meaning of the emblem, because so far the connection (i.e. the interpretant) is still an arbitrary assumption existing in the mind of the initiators. To understand what the political emblem means, besides the obvious move of explicitly asking for explanations, individuals can proceed by abducing beliefs and desires from actions and contents of speeches of the party members. When these mental states are considered to plausibly justify action, they can infer the arbitrary connection with the artefact. In both the introduced cases, however, it appears clear that the communicative targets must become aware of the mental states in the mind of the initiators. They must also become aware of the arbitrary connection they have in mind, either explicitly (via linguistic interaction) or implicitly (via abduction). In the maintenance phase, the arbitrary relation that connects artefacts and mental states becomes shared as a form of social knowledge and people aware of the connection allow newcomers to become aware of the arbitrary relationship.

An interesting modern day example of symbolic body adornment is offered by punk subculture. Punk appearance includes a broad set of accessories and gadgets that embody beliefs in punk subculture values. Razorblades, wasted materials, safety pins, Mohican haircuts, piercings and tattoos not only mark a physical distinction from the average member of an industrialized society, but also represent a set of abstract values such as rebellion, nihilism and anarchy (Hebdige 1979; De Mello 2007). By using razorblades as beads, for example, punks aim to provide a grotesque reproduction of the mainstream use of jewels in bourgeois society. In the initiation phase, the indexical association existing between wealth and social status is therefore extrapolated from the context and manipulated to produce a paradoxical outcome. In this way, the razorblade pendant embodies the destruction of meaning that industrialized societies ascribe to jewellery. To *understand* the real meaning of this ornament, the observer is called to reason about a theory that explains the use of jewellery in industrialized societies. Then, she can try to categorize punk ornaments by comparing them with this theory. In this way, the paradox emerges and the observer would have to provide a best explanation for the punk to behave in such a way. Clearly, this taps into a level of mindreading that enables the prediction of the values held by members of this subculture. However, since these values stem from criticism of mainstream ones, the computational demands of making sense of these artefacts disproportionally increases. Indeed, the observer has to represent mental states of bourgeoisie people and to embed them within mental states of punk subculture. In doing this twofold form of mindreading, the observer needs also to understand the relationships between these different mental states and their respective ornaments (i.e. jewels and razorblades). When punk symbolism becomes part of a shared social knowledge, members of this subculture have good reasons to *maintain* this practice.

Even though they represent quite extreme examples of symbolism, political emblems and punk ornaments clearly elucidate how full-symbols can be radically different from aesthetic and indexical ornaments discussed earlier. In the light of the semiotic, conceptual and socio-cognitive aspects that discussion covered, it seems quite reasonable to claim that strategies grounded on direct social perception, enaction and long-term construction of perceptual representations are not sufficient to effectively explain this category of signs. The intricate networks of theories, mental states, conventional connections involved in these practices seem to necessarily require high-level cognition and theory of mind.

5 Discussion

By revisiting H&D's proposal with the approach adopted here, it should appear now clear that the three grounding phases for body adornment previously introduced can be fully supported by a set of highly demanding mentalistic strategies. These consist of ascribing to body ornaments the concept of COOLNESS, which is then individuated in the minds of conspecifics by a process of full-blown mindreading. If, as previously argued, COOLNESS ought to be intended as an abstract theory, then it follows that the computational load required to perform this mindreading task would disproportionally increase. Indeed, observers must justify body adornment by inferring its meaning from a network of relations that connect COOLNESS, artefacts, makers and actions, which in turn embeds another network of inferences (the theoretical definition of COOLNESS).

In consequence, the cognitive processes that one can individuate in H&D's proposal at least for the understanding and maintenance of early body ornaments are broadly consistent with those I introduced for the category of full-symbolism. They seem to be at least qualitatively similar to those involved in the production and use of extreme forms of symbolism, namely political emblems and punk ornaments. Clearly, cases of full-symbolism are rather common in contemporary human societies. At the same time, it still needs to be established whether this phenomenon could be considered as "primary" when contemporary populations produce body adornment.

Nevertheless, there is no doubt that these mentalistic strategies are in principle sufficient to initiate, understand and maintain any practice of body adornment. However, the crucial problem with H&D's proposal is that it assumes mindreading of abstract theories to be also necessary to explain early body adornment. From this premise it follows an automatic chain of inferences about cognitive equivalence. If early body ornaments need the symbolic/mentalistic requirements they propose, then the makers of these artefacts had a cognitive architecture capable of handling these highly demanding processes. This allows one to conclude that early anatomically modern human and late Neanderthal populations had a cognitive architecture at least not significantly different from the Upper Palaeolithic ones.

However, I defend the thesis that full-blown mindreading and abstract shared theories represent only a logical possibility, which finds no necessary constraint in the artefactual record. Alternative strategies in ascribing meaning to ornaments and cognitively processing them could be advanced, and these alternatives do not imply the requirements suggested by H&D.

A first step along this path could involve considering early body adornment as a personal phenomenon (Coolidge and Wynn 2011). This approach seeks to eliminate the necessity of abstract shared standards and full-blown mindreading by removing communicative targets from the scene. Besides the validity of such a proposal, which ought to be separately discussed, I propose instead to keep communicative targets and the interpersonal dimension, while eliminating only the necessity to process body ornaments with mentalistic strategies and abstract shared concepts.

In order to make sense of body ornaments, there is no need to create a shared mental dimension, from where concepts are extracted and applied to artefacts. On the contrary, meaning can be situated directly in the patterns of action and perception underlying social phenomena. In this way, meaning emerges from a dynamic system created when intentional actions of the initiator become, through the artefact she handles, coupled to the re-actions of the observing others. In the toy example concerning aesthetic artefacts, Sally's nugget acts as an interface that connects her artefact-holding hand to the embodied emotional response that is showed by conspecifics. It allows Sally to get aware of the meaning of the stone in that context, by conveying embodied actions and orienting them towards the body/artefact complex. A similar point applies also to Adam's indexical case, where a causal connection between a dead dangerous animal and Adam's capabilities replaces the nugget's aesthetic disposition. Artefacts act therefore as material scaffolding for directly perceiving the surrounding others' intentional reactions. In doing this, they contribute to eliminating the need for mental states to be individuated as such in the other people's heads. At the same time, the long-term relationship between artefacts and humans contributes to creating situated concepts of *extended individuals*, which in turn shape developmental context for future generations. Artefacts allow therefore to re-enact and bind together perceptual simulations of events and actions that are relevant for the emergence of meaning. This eliminates the need to invoke abstract theories as necessary to make sense of early body ornaments.

Crucially, the cases discussed in the *Aesthetic* and *Indexical* sections also apply to the use of beads and ochre pigments as body ornaments. Beads can be instituted as a body adornment practice in the form of enacted aesthetic ornaments. The enactive strategies reported for gold nuggets can arise from a preliminary intrapersonal level where pearled and coloured shells are collected for self-reward. Indeed, the existence of collections of objects that are remarkable in one way or another has been reported in the archaeological record (Schäfer 1996; Soressi and d'Errico 2007; Moncel et al. 2012). Then, from a private collection, the whole set of enactive strategies could drive the three grounding phases. Furthermore, a phenomenon of *semiotic metamorphosis* could gradually reveal an indexical relation that connects beads to cool and wealthy individuals. If beads were moved from one location to the other for their aesthetic value, it is possible that their rarity and demand slowly brought forth to consciousness an indexical relation lying initially in the background. Again, this semiotic metamorphosis could be happening as a result of long-term interaction with extended individuals and rare materials, which does not necessarily require theoretical concepts and full-blown mindreading.

Situated cognitive strategies appear in sum to be sufficient to explain the emergence of beads and ochre pigments in the form of aesthetic and indexical ornaments. This new set of explanations removes the conditions of necessity that link early body ornaments found in the archaeological record to the mentalistic explanations advanced by H&D. In other words, nothing associated with beads and ochre in that record necessarily constrains the plausibility of full-blown mindreading and theoretical concepts. For no necessary constraint in the record points to conditions that imply the presence of an ornamental system qualitatively comparable to punk symbolism or political emblems.

Importantly, situated strategies for early body adornment thoroughly redefine the cognitive processes required to handle production and use of early body ornaments. While H&D consider high-level *social cognition* as necessary to this purpose, I think that an approach mostly grounded on *social perception* can do large part of the job without adopting the same costly cognitive processes.

This clearly does not entail that every aspect of the three grounding phases to be established through direct social perception. Despite the fact that this perception can be "smart enough" (Gallagher 2008) to obviate the need for attributing mental states to others, it appears clear that some steps within the three phases require a form of decision-making and action-planning. This is particularly evident, for example, when the initiator of the practice has to decide to turn an item (e.g. a gold nugget) into a body ornament (e.g. a gold bead). In consequence, it is necessary to justify what kind of processes are involved in this form of planning and how they can cope with the set of situated strategies previously reported. In the context of the debate about cognitive evolution/equivalence, it becomes vital to identify and clearly spell out this new body of cognitive requirements carried by the situated approach. In particular, the interaction between direct perception, situated concepts and executive functions, such as manipulating information in working memory and inhibiting irrelevant one (see also de Bruin et al. 2011 for an analogous problem in developmental psychology), represents an important target for future analyses.

Once these requirements are clarified, a key topic for the equivalence argument regards the relationship between non-symbolic ornaments, situated strategies and cognitive architectures. The cognitive processes proposed by H&D are considered as signature of modern cognition. If these capabilities are not necessary to process early body ornaments, there exists the possibility that a modern cognitive architecture is not necessary either. The existence of beads and ochre pigments in the archaeological record is compatible therefore with a cognitive architecture capable of implementing the minimalistic strategies discussed so far. However, given our current state of knowledge, it is not possible to conclusively state that this mental architecture has the properties to process also full-symbols. Once the necessity to call for the mentalistic capabilities invoked by H&D is ruled out, the next step lies in examining whether the set of situated strategies proposed here still requires modern cognitive architecture. This needs further analysis of candidate architectures (Barnard 2010b; Carruthers 2006; Paivio 2007; Shallice and Cooper 2011) with clearly defined components and rules that govern their interactions. The aim of this analysis should be to identify the minimal properties an architecture must have to handle the situated processes early body ornaments require to be produced (and in particular the cognitive operations they entail). The core of a cognitive pluralist agenda lies in showing that a primitive cognitive architecture, albeit possibly augmented in the capacity of information carried

(Garofoli 2013) and capable of implementing situated processes, is sufficient to produce non-symbolic body ornaments. If this argument could be plausibly supported, then the presence of beads and ochre in the record would not prove cognitive equivalence between contemporary and primitive populations. On the contrary, the possibility that primitive, though augmented, architectures (Barnard et al. 2007, p. 1171) played a pivotal role even in the most recent stages of human evolution would become central to the cognitive evolution debate.

6 Conclusions

This paper has not sought to systematically question the cognitive equivalence agenda. My formulation shows that H&D's (2011) argument is insufficient to support it. Indeed, if beads are to be considered aesthetic or indexical ornaments, a body of situated cognitive strategies, albeit only sketchily introduced here, appears to be sufficient to explain their adoption without necessarily involving full-blown mindreading or theoretical concepts. Since a non-modern cognitive architecture could implement these minimal strategies, cognitive modernity/equivalence does not necessarily follow from the presence of beads and ochre pigments in the archaeological record. Further research is required to assess the plausibility of the connection between primitive cognitive architectures, situated strategies and early body ornaments.

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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 neuro-archaeological 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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