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978-0-521-76977-8 - Cognitive Archaeology and Human Evolution

Edited by Sophie A. De Beaune, Frederick L. Coolidge and Thomas Wynn

Excerpt

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CHAPTER 1

The emergence of cognitive abilities: The contribution of neuropsychology to archaeology*Sophie A. de Beaune*

The cognitive abilities of the ancient hominins appear to have progressed relatively slowly, insofar as the material evidence that they left behind is concerned. In fact, their technical productions, which appeared more than 2.5 million years ago, improved very little for nearly the entire period (i.e., about 2 million years). In contrast, the evidence of nonutilitarian practices, such as the burial of the dead or the first graphic expressions, made their appearance much later, not before 100,000 years ago. In addition, the human fossils themselves indicate a gradual evolution of uniform growth of the brain size.

We can query about the emergence conditions of these material and “symbolic” productions and ask why only the human species could develop it. If we admit that they reflect a modification of cognitive skills, then it is advisable to wonder of what these capacities consist. We could thus question the capacities of anticipation of the handaxe toolmakers or the capacities of abstraction and symbolization of the first people who buried their dead.

We could also seek to understand the conditions that led to the installation of a variety of cognitive processes during evolution. Are the processes developed answers to the requests of a changing environment, or are they the result of an evolution of the neurophysiological organization of the brain? Were the processes simply a better use of anatomical and cerebral structures already installed at the beginnings of the hominization? It is also possible to consider a more active role of hominins in their own development and to query about the impact of their activity in the emergence of new cognitive abilities.

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One can also ask whether there is something specific to the human species that could explain why the nearest relatives of the hominins, the apes, do not seem to have access to such cognitive aptitudes, at least not in such a developed and systematic manner. Are these differences the result of simply diverging processes in species with equivalent potentialities at the beginning? Are there neurophysiologic differences important enough to explain these differences in ability? Or is it the aptitude to transmit their knowledge to the following generations that would distinguish the human primates from the nonhuman primates?

All of these questions and many others deserve to be debated. This is why it seemed to us that it could be profitable to gather prehistorians and neuropsychologists, both interested in the question of the emergence and evolution of cognitive abilities, so that they could confront and share their points of view and their knowledge.

This book¹ presents the results of both empirical studies and theoretical speculations about the emergence and the evolution of modern thinking, with evidence coming from both archaeology and neuropsychology. We explore the cognitions required in the making of simple stone tools to more sophisticated production, such as symbolic thought or language. Traditionally, these two fields of study have shared little in the way of theories and methods, yet they both provide crucial pieces to the puzzle of modern human cognitive emergence and evolution.

Cognitive archaeology is a quickly growing discipline. Ironically, archaeologists have been slow to adopt current theories, models, and findings within contemporary cognitive science. This book will serve as an example of the contributions of both disciplines.

1 Some of these chapters were presented as papers at the Congress of the International Union for Prehistoric and Protohistoric Sciences (IUPPS) in Lisbon, Portugal, on September 7, 2006, at a colloquium organized by Sophie A. de Beaune.

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CHAPTER 2

Technical invention in the Palaeolithic: What if the explanation comes from the cognitive and neuropsychological sciences?

Sophie A. de Beaune

The evolution of the cerebral capacities of humans, from the first hominins to modern humans, is at the heart of our interrogations. How can we explain the fact that only hominins seem to have developed the capacity for technical invention, in contrast to our closest relatives, the great apes? The archaeological data allow us to observe this phenomenon, but offer very little in the way of a response to this question.

By examining the possible contributions of other disciplines, particularly in the cognitive and neuropsychological sciences, we can ask if there exists a cause-and-effect relationship between the following phenomena:

- the archaeological data, which indicate that technical inventions throughout prehistory are increasingly frequent and complex from the first hominins to modern humans;
- the cognitive perspective, which seems to indicate that the processes of analogical reasoning are increasingly frequent through time, either for “statistical” reasons (a greater population density leads to a greater probability of the meeting of two ideas) or for cognitive reasons; and
- the palaeoanthropological data, which show that current neurological conditions developed progressively, with the frontal lobes and pre-frontal cortex becoming more and more accentuated from the first hominins to modern humans.

We will explore the possible contribution of a confrontation of these different disciplines.

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Invention processes: The archaeological data

Through the study of a certain category of archaeological remains – stone tools that are not flint – I have shown that the invention of new tools and new actions seems to have resulted from a combination of preexisting elements, rather than from creations *ex nihilo*, or an accumulation of knowledge. They were made possible by the fusion of two different technical actions, by the combination of a familiar action with a tool traditionally used for other purposes, or by the combination of a familiar tool with a new worked material (de Beaune 2000, 2004, 2008). To briefly recapitulate this process, I will present some examples, the first of which comes from my own investigations of nonflint stone tools.

During the Neolithic period, the technique of polishing with a fixed polisher on bedrock was extensively used to polish ax blades. This technique could be the result of a fusion of the technique of polishing long objects with a small, generally grooved, hand polisher during the Upper Palaeolithic and Mesolithic, and the full back-and-forth grinding technique, generally realized with two hands, which appeared at the end of the Upper Palaeolithic or Epipalaeolithic and was first used to grind wild cereal grains (de Beaune 2000, 186–187).

Pottery seems to have resulted from a combination of the idea of a container (which already existed in the form of skin, vegetal fiber, bark, and wood containers) and the baked-clay technique. Baked clay was already used as a coating for walls and floors, and later as an internal facing of pit hearths as early as the second phase of Mureybet, and then to shape figurines starting in Mureybet Phase IIIA (Cauvin 1978, 101; 1994, 64).

Another much earlier example has been proposed by Despina Liolios in the context of antler-working techniques, which would have been transferred from wood to antler during the early Aurignacian period (Liolios 2003).

Much further back in time, we could include the first attempts at bone shaping during the Middle or Early Palaeolithic, which consisted of no more than knapping techniques transferred from flint to bone. The result was the crude bone bifaces or bone side scrapers found in several sites, such as Castel di Guido and Fontana Ranuccio in Italy and Bilzingsleben in Thüringen, Germany (Biddittu & Segre 1982; Pitti & Radmilli 1984; Mania 1995).

We thus see that from the Early Palaeolithic to the Neolithic, innovations or inventions seem to have resulted from the same process of technical

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transfer, meaning the combination of two already existing, but independent, technical ideas. These combinations did not arise from nothing, but rather from an association in the mind of things until then dissociated in experience.

In this way, the increase and diversification of inventions and innovations through time could simply have resulted from a demographic increase, which favored the opportunity for technical confrontations. However, we must keep in mind that the combination of two technical ideas is neither systematic nor necessary, and that it is possible for two ideas never to meet (for example, the idea of the wheel and that of the carriage for the ancient Mexicans).

In the same way, an “invention” can remain with no outcome if it is not adopted by the group, and in this case it is very unlikely that it would be recognized by archaeologists.

The term “exaptation” introduced by Stephen Jay Gould and Elizabeth Vrba (Gould & Vrba 1982) designates something that emerges from a context before its exploitation in another one. In other words, the word defines the choice in the present to use elements initially destined for other functions (or no function) for certain purposes. As an example, they cite the case of an African lizard whose extremely flat head constitutes an adaptation to life in crevices, but which also permits the animal to slide better.

Exaptation is in a way opposed to adaptation because, whereas adaptation implies a modification of a function to allow different uses, exaptation is the adoption of a character that had one use in an ancestral form and a new and different use in a descendant form.

Exaptation could explain how complex physical characteristics can evolve from initial simple structures. In fact, the term better clarifies the technical invention process in question here.

Invention processes: The cognitive perspective

These few examples of technical inventions could result from the well-known cognitive capacity of analogy. To cite Le Ny from his preface to the book *Analogie et Cognition*, “analogy, in its broad sense, and its cousin, resemblance (or similarity), is probably the basis of many automatic cognitive activities, and I am not far from thinking that it is one of the fundamental determinants of cognitive functioning” (Le Ny 1999, x). More precisely, the functioning of analogy in problem solving, in the generation of scientific

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hypotheses, or in declarative knowledge attainment, as in many other cognitive domains, is always based on the capacity to perceive and use analogous facts. In other words, it is based on the capacity to establish a link between two domains and transfer a familiar procedure from one situation or class of situations to a new situation that is similar though not identical (Le Ny 1999, xiv).

The three following questions thus arise: What exactly is the process of analogical reasoning? Is it specific to humans? If so, when did it appear?

What is the analogical process?

The analogical process can easily be summarized as follows: When people are faced with a new situation or problem, they look for a similar problem or situation in their anterior experience for which they had found a good solution.

This strategy implies two types of mental representation: those stocked in the long-term memory, and transitory representations, meaning those used during information treatment that correspond to the working memory, including old representations reactivated in the moment of their treatment.

Although referential knowledge is essential, two other cognitive tools are also necessary for its utilization: abstraction and generalization (Gineste 1997, 86, 119).

Obviously, differences exist between a so-called expert, who has already confronted an analogous problem and who possesses structured and stabilized knowledge in the long-term memory, and a novice confronted with a new problem. The latter must establish a link between two domains and transfer a familiar procedure from one situation or class of situations to a new situation that is similar though not identical.

In spite of some minor theoretical differences, most cognitive psychologists agree on the manner in which the analogical process functions and its importance in the processes of invention and problem solving.

Is analogical reasoning specific to humans?

Chimpanzees occasionally use transfer to solve a problem or a situation. However, this capacity, known as competence transfer, has been observed only in captivity and uniquely among subjects educated in experimental-language training. This is the case with Sarah, studied by David Premack

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(Premack & Woodruff 1978; Byrne 1995, 84–85), in the particular context of spatial competence.

The lack of inventiveness of chimpanzees could be explained as an absence or only minor development of their long-term memory. However, it is true that researchers have mostly studied the phenomenon of working-memory recognition, whereas studies concerning the recall of long-term memory have been neglected. This is perhaps because the latter is considered to be exclusively linked with linguistic information and thus inaccessible in the study of species lacking language (Vauclair 1992, 106). The only case of this type yet studied is that of Sarah.

If apes do have access to information stored in the long-term memory, their lack of “inventiveness” could be due to a lack of need for it in their natural environment, or a lack of social motivation. The chimpanzee Sultan, studied by Köhler, showed analogical reasoning. However, this remains an isolated and individual case and he did not transmit it to other members of the group (Köhler 1925). In other words, these aptitudes do not occur in nature because there is a lack of need or a lack of social connections between individuals.

When did analogical reasoning first appear among the hominins or first humans?

The degree of complexity required to realize a biface implies the capacity to preview and plan certain operational stages. It is obvious that working memory is not sufficient here and the recovery of long-term memory is necessary. We can thus conclude that *Homo erectus* was able to perform analogical reasoning.

Before this time, we can consider that the realization of choppers or chopping tools might depend only on the working memory. The capacity of this memory is weak – implying no more than 7 ± 2 units – and rapidly forgotten, in about 20 seconds, but it is sufficient to realize a cutting edge.

Meanwhile, the invention of stone knapping itself results from the technical transfer of an action to a different material. The percussion movement used to crack bone or hard fruit could have led to the use of percussion to obtain a cutting flake (de Beaune 2000, 176–179). This invention could have occurred in three stages.

The first stage corresponds to the use of cobbles or blocks to crack bones, hard fruits, or wood. An accidental flake is produced. The author of the

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action can store it – or not – to use it. This attitude, observed among modern chimpanzees, could have occurred among Australopithecines.

In the second stage, similar actions are employed but now the user focuses on accidental debris. Flakes serve as knives or scrapers to cut, scrape, slice, or saw animal or vegetable materials.

Though chimpanzees rarely act in this way, it is probable that the earliest Australopithecines used such flakes to scrape the buried parts of plants, for example. Among the activities that could have accidentally produced flakes, we can consider nut cracking, which is performed by some chimpanzees, or the cutting up of carcasses, unknown by chimpanzees, but perhaps practiced by some Australopithecines.

In the third stage, the deliberate will to produce flakes by knapping a cobble with a hammerstone appears. The hammerstone thus becomes a basic tool that serves to produce flakes from a block or nodule, which is now transformed into a core. The artisans are now interested not only in the intentionally produced flakes, but also in the cobble or block with a sinuous edge on one of its extremities and a blunt surface for holding on the other. These are choppers. The most recent Australopithecines, *Paranthropus*, or the first humans were certainly the first actors in this third stage.

Marchant and McGrew have recently proposed a similar hypothesis (Marchant & McGrew 2005). If we accept such a scenario, we must admit that these first knapping tools provide some evidence for the capacity for analogical reasoning, but we do not yet know who among these first hominins possessed this capacity.

Invention processes: The neurological perspective

These data concerning the link between neuronal evolution and the evolution of cognitive capacities are contradictory. All researchers recognize that brain growth during hominization, which is shown by an increase in the thickness of the cerebral crust and in the size and ramification of neurons, would have led to a greater richness in the interneuronal connections, which itself would have led to a significant improvement in cognitive capacities, as shown in Figure 2.1 (also see Changeux 2000, 196).

The figure shows the topography of the meningeal vessels on the parietal bone of some hominins. This regulatory system, which is physiologically very important, is linked to the effective functioning of the brain. Known through endocranial casts, it shows a gradual increase in complexity during

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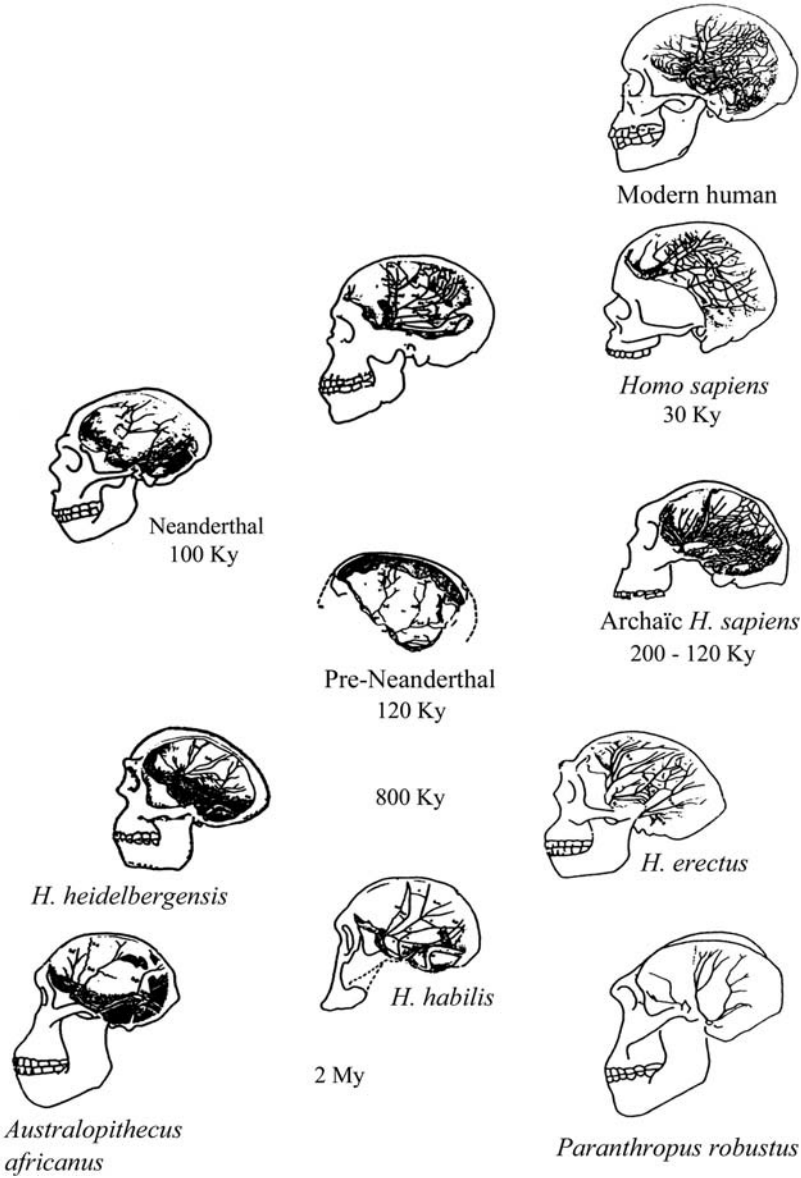


FIGURE 2.1. Topography of the meningeal vessels on the parietal bone of some hominins, adapted from Saban (1995). The possible filiations and hybridizations indicated by Saban by continuous or dashed lines are now outdated. (Courtesy of Elsevier Masson.)

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hominization. This topography was compared by Saban with those of young modern children during their development. It is remarkable to observe that the topography of the meningeal vessels of *Paranthropus robustus* (cranial capacity: 520 cc) resembles that of a modern newborn; that the distribution of the vessels of early humans (*Homo habilis*, cranial capacity: 700 cc) is close to that of a 40-day-old modern child, and that of *Homo erectus* from Java (cranial capacity: 1,000 cc) resembles that of a 1-year-old modern child.

Moreover, researchers agree that brain growth primarily concerns the neocortex, and, more precisely, the frontal lobe, which is very important in human beings because it represents nearly one third of the cerebral volume. This aspect developed considerably during hominization, the earlier hominins having a supraorbital torus that blocked the development of the skullcap above the forehead.

But here is where the unanimity of opinion stops. For a precise understanding of the link between human cognitive capacities and cerebral organization, there exist two main, and rival, theses: localizationism and connectionism.

Localizationism

Supporters of localizationism, known as localizationists, suppose the existence of a correlation between mental functions and specific areas of the brain. Arising at the beginning of the nineteenth century, this theory was greatly developed following the creation of a cerebral map. More recent cerebral imagery seems to point in the same direction.

The frontal lobe, which is of specific interest to us here because it is the one that developed the most during hominization, seems to be the center of reflexive conscience and upper psychism. It is here that intentions seem to arise and where programming, initialization, and control of voluntary behaviors seem to occur. In any case, researchers agree that certain complex apprenticeships, such as the solving of algebraic equations, multiple language learning, or motor abilities, take place in the prefrontal associative zones.

Moreover, analysis by positron emission tomography has been used to examine brain activation during experimental stone toolmaking (Stout et al. 2000). Experiments show that the main areas activated by an experienced modern knapper (neocortex and cerebellum) are exactly those that