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ORIGINAL SCIENTIFIC ARTICLE

Becoming Modern *Homo sapiens*

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Abstract Human beings are unusual in many ways but perhaps most strikingly in their unique symbolic form of processing information about the world around them. Although based on a long and essential evolutionary history, the modern human cognitive style is not predicted by that history: it is emergent rather than the product of an incremental process of refinement. *Homo sapiens* is physically very distinctive and is clearly the result of a significant developmental reorganization with ramifications throughout the skeleton and presumably beyond. It is reasonable to suppose that the neural underpinnings of symbolic thought were acquired in this reorganization. However, the fossil and archeological records indicate that the first anatomically recognizable members of the species substantially predated its first members who behaved in a demonstrably symbolic manner. Thus, while the biological potential for symbolic thinking most likely arose in the morphogenetic event that gave rise to *H. sapiens* as a distinctive anatomical entity, this new capacity was evidently exaptive, in the sense that it had to await its "discovery" and release through a cultural stimulus. Plausibly, this stimulus was the invention of language. One expression of symbolic reasoning is the adoption of technological change in response to environmental challenges, contrasting with earlier responses that typically involved using existing technologies in new ways. As climates changed at the end of the last Ice Age, the new technophile proclivity was expressed in a shift toward agriculture and sedentary lifestyles: a shift that precipitated a fundamentally new (and potentially self-destructive) relationship with nature. Thus, both of what are arguably the two most radical (and certainly the most fateful) evolutionary innovations in the history of life (symbolic thinking and sedentary lifestyles) were both very recent occurrences, well within the (so far rather short) tenure of *H. sapiens.*

Keywords *Homo sapiens* · Symbolic cognition · Human origins · Upper Paleolithic · Middle Stone Age · Human uniqueness · Exaptation · Emergence

Introduction

Becoming human (as we know ourselves today) was not a sudden, one-time event. Nor was it the culmination of a slow process of fine-tuning over many thousands of generations. Instead, the transformation of our precursors, from a readily recognizable (if rather odd) variation on the primate theme to the altogether unprecedented entity we are now, was both recent in geological terms and complex in its unfolding.

Modern *Homo sapiens* is an unusual creature in many respects. Most of our many physical peculiarities are in one way or another associated with our upright posture, a feature with a long, well-documented history. Nonetheless, the acquisition that gives us our strong feeling of qualitative difference from the rest of the living world lies not among our physical attributes but in our unprecedented form of cognition. Uniquely among living things, we human beings live not solely in the world as nature presents it to us but substantially in the world as we re-create it in our heads. We are able to accomplish this trick because we are symbolic creatures: we mentally decompose the world

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around us into a vocabulary of discrete symbols, which we can combine and recombine in our minds to envisage new possibilities and ask questions such as "what if?" As far as it is possible to ascertain, no other creature does that or has ever done it.

The Fossil and Molecular Records

Interestingly, the very first hominids (members of the human zoological family; an alternative adopted sometimes is to call them hominins, distinguishing them from their closest living cousins at only the subfamily level), who looked physically identical to us, do not appear to have behaved in this distinctive fashion.

In the fossil record of the past several hundred thousand years, a variety of morphologically different hominids is known. Partly because all had respectably large brains (even if not all were quite up to the modern average), most of them (with the traditional exception of the Neanderthals) were regularly classified as "archaic *Homo sapiens*." However, paleoanthropologists are increasingly beginning to recognize that this is a meaningless and inappropriate category (see discussion by Schwartz and Tattersall 2005); and, indeed, it is remarkable how poorly foreshadowed in the known fossil record the distinctive modern *H. sapiens* morphology is. Thus, while readily recognizable close fossil relatives are known for European *Homo neanderthalensis* (see Tattersall and Schwartz 2006), nothing comparable is as yet known for *H. sapiens*, though it cannot be ruled out that this is because the African record is as yet poorly sampled.

Living *H. sapiens* is highly distinctive in its bony structure. Cranially, our species is most remarkable for its short in lenght, tall-domed, rather balloon-like braincase, beneath the front of which a very small facial skeleton is distinctly retracted. Among other very unusual details of the face are (typically very small) ridges above the orbits (eye sockets) that are bipartite, i.e., divided into lateral and central sections by a distinct groove; and a complex chin structure at the front of the lower jaw that essentially takes the shape of an inverted "T" (Schwartz and Tattersall 2000). Like the skull, our body skeleton is lightly constructed, with a slender, parallel-sided thorax matching a narrow pelvis below.

The first fossil intimations we have of this characteristic modern bony anatomy come from Africa. A fragmentary skull from the Omo basin in southern Ethiopia has recently been dated (McDougall et al. 2005) to about 195,000 years ago. As reconstructed, it is large-brained and modern in general appearance, though it does not seem to have had typically modern brows and chin. Somewhat younger, at around 160,000 years, is another Ethiopian cranium, from Herto in the Middle Awash basin (White et al. 2003). This one lacks a lower jaw and, as illustrated (it is not available for independent examination), it appears damaged above the eyes; but apart from a possible lack of division in the brow, it seems to resemble modern humans pretty closely in other observable respects.

In their possible lack of a true chin and/or bipartite brows, both Ethiopian specimens recall a small suite of younger (some very much younger) fossils from southern Africa that include the Fish Hoek, Boskop, and Border Cave 5 crania (Schwartz and Tattersall 2005). This mutual resemblance suggests that not only the South African fossils, but also Omo 1 and Herto, may well be *H. sapiens* that happen to lie just outside the documented modern envelope. At the very least, the Omo and Herto fossils demonstrate that by close to 200,000 years ago the basic modern *H. sapiens* morphology was already established. The fixation in our lineage of the new cranial (and by extension postcranial) morphology resulted very probably from a single change in DNA regulation, the developmental consequences of which positioned the new species *H. sapiens* as anatomically quite distinct from its nearest African relatives (some of which, at least, lingered on until well after 200,000 years ago).

The fossil evidence that *H. sapiens* emerged as a recognizable anatomical entity in the period immediately following 200,000 years ago is corroborated by molecular studies of modern human populations (e.g., Harpending and Rogers 2000) that converge on a common ancestry for all extant populations of *H. sapiens* within this approximate time frame. Analyses of DNA diversity among peoples from all over the globe also indicate that the ancestral human population originated in Africa, where genetic diversity is greatest (and has thus been accumulating longest). The founding population, most recently suggested to have lived in southwestern Africa (Tishkoff et al. 2009), subsequently spread out to colonize the rest of the continent and ultimately the rest of the world. A typically modern human skeleton from the Israeli site of Jebel Qafzeh, dated to 93,000 years ago, shows that anatomical moderns had spread beyond Africa proper by that time. However, molecular analyses as well as archeological considerations (see below) suggest that this occupation of the Levant was ephemeral and that the definitive human exodus that gave rise to all extant human populations came later than this, at around 85,000 years ago or less (Harpending and Rogers 2000).

Over the next ten thousand years, the descendants of these early emigrants moved eastwards along the southern coast of Asia, reaching China by about 75,000 years ago. Australia may have been colonized (necessarily using boats) by about 60,000 years ago. Warming of the climate around 50,000 years ago allowed reinvasion of the Levant

and the Fertile Crescent region to its north; and by about 40,000 years ago, *H. sapiens* was entering Europe and central Asia. By 25,000 years ago, northeastern Eurasia had been occupied, all the way to the Arctic Circle. Perhaps as early as 20,000 years ago, and certainly within a few thousand years of this date, populations had entered the New World via a Bering Straits Land Bridge exposed by low glacial sea levels. Indications are that people had reached Chile by almost 15,000 years ago, possibly following the coastline in boats.

Symbolism and the Archeological Record

Significantly, the archeological associations of the earliest anatomical *H. sapiens* are almost spectacularly unimpressive. The few stone tools reported from the same sediments as the Omo 1 cranium have been described as "unremarkable" (Klein 1999), while those from the deposits yielding the Herto cranium are notably archaic, consisting of some of the latest recorded African handaxes (large, teardrop-shaped bifacial implements that had by that time been made continuously in Africa for almost 1.5 million years), plus some Middle Stone Age elements, roughly equivalent to the productions of Neanderthals (Clark et al. 2003). This lack of association between the new kind of hominid and any identifiable technological innovation actually echoes a longstanding theme that goes back to the very beginnings of archeology: the first stone tools were evidently made by "bipedal apes" that were otherwise not detectably different from their non-toolmaking predecessors; and the appearance of the first hominids to have possessed essentially modern body proportions was not accompanied by any evidence of significant technological change. Though perhaps counterintuitive, these observations actually make good practical sense; for the inventor of any new way of doing things has perforce to belong to a pre-existing species.

The technological history of Hominidae following the invention of stone tool making some 2.5 million years ago was thus much like the life of a soldier: long periods of boredom punctuated by moments of sheer terror. Sporadic innovations were followed by vast stretches of time bereft of significant novelty. Technologies did their job, and hominids simply used them to do whatever was necessary as environments fluctuated. This longstanding pattern only ever changed once, and very recently. The change is best exemplified in Europe, where the well-documented arrival of *H. sapiens* about 40,000 years ago was accompanied by a restless creative spirit that expressed itself in the constant pursuit of the new (White, 1986, 2003). The best-known manifestation of this new creative spirit was the art executed and preserved within caves such as Chauvet, Lascaux, and Altamira—art that includes some of the most powerful, deft, and closely observed ever made, and that was clearly executed in the service of highly complex systems of belief. But the creative urge went far beyond these mural images to include elaborate self-ornamentation, the almost compulsive and often ethereally beautiful decoration of everyday objects, the creation of complex musical instruments, the development of systems of notation, and a host of clever new technologies.

These new technologies were plausibly spurred by changes in environmental circumstances, to which this innovative response by the early European *H. sapiens* was altogether unprecedented. Previously, hominids had accommodated to environmental challenges by emigration or by adapting existing technologies to new uses. But the "Upper Paleolithic" Europeans were responding to external stimuli by coming up with new technologies, just as we do today. Nobody looking at the messages implicitly embedded in the succession of material cultures left by the Upper Paleolithic societies of late Ice Age Europe, either from an aesthetic or from a technological viewpoint, can doubt that these cultures were the product of beings that possessed fully modern symbolic sensibilities.

The early *H. sapiens* who invaded Europe (evicting the resident and almost certainly nonsymbolic Neanderthals in the process) evidently arrived there with their symbolic capacities fully formed. We see no process of transformation in the archeological or paleontological records. With a very few local and invariably arguable "post-contact" exceptions, the material leavings of the "Middle Paleolithic" Neanderthals in Europe were abruptly replaced by those of the *H. sapiens* who succeeded them. The symbolic ability we see embodied in the European Upper Paleolithic must have evolved elsewhere before the arrival of the newcomers.

In very instructive contrast to the European situation, the early *H. sapiens* who penetrated the Levant by around 100,000 years ago seem to have wielded Middle Paleolithic technologies identical to those of the Neanderthals who somehow shared the region with them up to about 45,000 years ago (Bar-Yosef 1993). It is not known whether the two hominid species partitioned the landscape concurrently or whether, perhaps, the Neanderthals moved in during cold times while the early *H. sapiens* predominated during warm ones; but whatever the case, there is no evidence for any behavioral or cognitive difference between the two species over this period. Indeed, it was only after the local invention of a stone toolkit equivalent to that of the European Upper Paleolithic that the Neanderthals disappeared. And although we have no direct evidence bearing on what kind of hominid invented this new toolkit or on what other behavioral changes might have been implicated in its appearance, it is a very good bet that the new technology was the product of anatomically distinctive *H. sapiens*.

Since cognitive states do not preserve directly, they have to be read from proxy evidence. And inevitably, specialists disagree as to what kinds of material indication can be viewed as satisfactory proxies for symbolic cognition. It has periodically been suggested that complex stone working technologies require language (and by extension symbolic abilities) for transmission down the generations; but experiments by Japanese researchers (Ohnuma et al. 1997) suggest that this is not the case. Indeed, there is a strong argument to be made that no aspect of Paleolithic technology can by itself be taken as prima facie evidence of symbolic capacities; for intuitive, nondeclarative, forms of intelligence can evidently accomplish formidable feats (Tattersall 2009). Only in the presence of overtly symbolic objects can we be confident that their makers were thinking symbolically.

The earliest intimations of symbolic thinking, as thus expressed, come from Africa. Researchers at the site of Blombos Cave, close to the continent's southern tip, recently reported the discovery of ochre plaques engraved with regular geometric designs (Henshilwood et al. 2003). Found in a Middle Stone Age industrial context, these objects are dated back about 77,000 years; and their interpretation as symbolic is reinforced by the subsequent finding at the same site of gastropod shells pierced for stringing (Henshilwood et al. 2004). Body ornamentation has profound symbolic implications in all modern societies, and many believe that it is not unreasonable to infer this for earlier societies too. The Blombos evidence is supported by similar "beads" found at other African Middle Stone Age sites, including the 82,000 year-old Grotte des Pigeons in Morocco (Bouzouggar et al. 2007) at the other end of the continent. Interestingly, a possible occurrence of similar kind has recently been reported just outside Africa, at the >100,000 year-old Israeli site of Skhūl (Vanhaeren et al. 2006).

Earlier than this, possible intimations of symbolism become more difficult to accept. For example, the pigment processing and shellfishing recently reported from the site of Pinnacle Point on the southern African coast at about 160,000 years (Marean et al. 2007) are arguable as markers for "modern" behavior patterns. This is especially the case given that both of these economic activities are documented for the almost certainly nonsymbolic *H. neanderthalensis* (Stringer et al. 2008). And claims for "symbolic" organization of the living space at the approximately 100,000-year sites of Klasies River Mouth in South Africa (Deacon and Deacon 1999), while interesting, are necessarily inferential.

The Transition(s)

Current evidence thus strongly suggests that the appearance of *H. sapiens* as an anatomically distinct entity, at around 200,000 years ago, considerably preceded the first unequivocal expressions of symbolic cognitive processes (under 100,000 years ago). The simplest way of explaining this disconnect (which, remember, reflects the typical pattern for biological and behavioral innovations in human evolution) is through the routine evolutionary phenomenon of exaptation, whereby existing structures are recruited to new purposes. The four limbs of tetrapods were acquired in an aquatic context long before becoming essential for terrestrial locomotion; and birds possessed feathers for many millions of years before using them for flight. Similarly, it seems reasonable to suppose that the neural substrate underpinning symbolic cognition was initially acquired in the major developmental reorganization that gave rise to the distinctive modern human anatomy and that the new potential inherent in the reorganized brain remained unexpressed until it was "discovered" through the action of what was necessarily a cultural stimulus. The best candidate we have for such a stimulus is the invention of language. Language is, after all, the ultimate symbolic activity and one that is inextricably entwined with symbolic consciousness as we experience it today. It is virtually impossible to envisage one in the absence of the other. What is more, we know that language can be contrived spontaneously by nonlinguistic modern humans, as in the recent creation of a sign language by deaf Nicaraguan schoolchildren (Kegl 2002).

The transition from a nonsymbolic, nonlinguistic cognitive state to a symbolic, linguistic condition is a virtually unimaginable one. Indeed, almost the only reason for believing that it *could* be made is that, inescapably, it *was* made. For this extraordinary switch was a qualitative leap rather than an additive refinement of a pre-existing system. Of course, it was based on an extremely long and accretionary history of vertebrate brain evolution, and it would have been impossible in the absence of any aspect of that history. But it was not predicted by anything in that history, and symbolic cognition is not just a better version of what was there before. Albeit superimposed on a pre-existing cognitive system, symbolic reasoning is a truly new method of processing information about the surrounding world; and, although many like to view it as the outcome of a long process of generation-by-generation fine-tuning, it is in fact best explained by emergence, the phenomenon whereby a chance combination of elements gives rise at once to an entirely new level of complexity (Tattersall 1998).

What is perhaps most counterintuitive of all is that this cognitive transition took place well *within* the tenure of our species *H. sapiens*. And since this momentous transition occurred, mankind's history has largely been a matter of discovering how the resulting potential could be used—a process that is abundantly observable today in our rapidly

proliferating technologies and art forms. Sadly, beyond a few isolated hints, we have no evidence of what exactly transpired in between those first stirrings of the human symbolic spirit in southern Africa and the torrential outpourings of symbolic behaviors by the early modern Europeans some sixty millennia later. But we can be reasonably sure that the intervening period saw an unsteady exploration of the possibilities inherent in their new and distinctly non-fine-tuned creativity, as the tiny and scattered early *H. sapiens* populations were buffeted by major climatic and environmental vicissitudes. The most fateful of those explorations took place at the end of the last Ice Age, when a true revolution in lifestyle occurred.

The "Declaration of Independence"

Like their ancestors in an unbroken succession, the earliest *H. sapiens* were hunter-gatherers, exploiting the natural bounty of the landscape. This basic lifestyle continued essentially undisturbed right through the end of the Pleistocene, although clearly both social lives and means of exploiting the environment became more complex following the acquisition of symbolic thought. However, as the climate warmed, around 11,000 years ago, climatic stresses and environmental instability in a number of different regions of the world began to stimulate humans to start cultivating plants and domesticating animals—again, showing the typical modern human propensity to develop new technologies in response to environmental challenge. With these economic innovations came demographic change and the adoption of settled ways of life.

One of the several independent centers of plant and animal domestication worldwide, and possibly the earliest (though it is now being run very close by China), was the Fertile Crescent of the Near East, the area that arcs northward from Israel through Syria and Turkey and east and south into Iraq and Iran (see overview in Tattersall 2008). People in this region who had come to depend on gathering wild cereals found this resource diminishing at the end of the last Ice Age, as summers became longer and hotter and aridity increased. In compensation, they initiated a process of cultivation and artificial selection that necessitated a sedentary lifestyle.

This relatively recent event constituted the most radical economic, social, and demographic shift in the entire long history of mankind, and its consequences not only reverberate but continue to gather momentum today. Most importantly, for the first time humans found themselves in opposition to Nature rather than living by its rhythms. And this fundamentally changed the way in which people viewed themselves and their place in the world.

In his book *Dominion* (Eldredge 1997), the co-editor of this Journal points out that historically documented hunting-gathering peoples have tended to see themselves as integral parts of the environment that supports them: to identify with it and to feel responsibility toward it. Agriculturalists, on the other hand, find themselves in opposition to nature. Rain does not fall at their convenience, nor does the sun shine; and life inevitably becomes a struggle to modify natural processes and, if possible, to dominate them.

Eldredge finds powerful echoes of changed attitudes in the founding documents of the Judaeo-Christian religions, the work of the descendants of those earliest farmers. Indeed, he characterizes the opening words of the Book of Genesis ("God said ... be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion ... over every living thing ...") as "the most ringing declaration of independence ever set down" (1997: 101). He refers, of course, to independence from the environment; and this declaration certainly summarizes the major elements that have bedeviled humanity's relationship with the ecosystems that sustain it ever since. Hunter-gatherers live in sustainable low densities, whereas agriculturalists need hands to till the fields and tend stock. But extra hands bring with them extra mouths; and the larger the population, the more vulnerable it becomes to fluctuations in agricultural productivity. These natural oscillations place populations on a sort of technological treadmill, leading to ever more intensive exploitation of environmental resources: an exploitation that in turn becomes ever harder to sustain in the face of natural climatic cycles. And, as a result, the history of mankind since the adoption of sedentary lifestyles has largely been one of local population increases, followed by economic collapse and social disintegration.

Conclusion

The history of humankind is a long one, extending back to the first "bipedal apes" some seven million years ago. Following the appearance of these unusual primates, evolutionary changes in the hominid family were highly sporadic, producing for the most part organisms or technologies that did what their predecessors had done, if a little better. The most radical subsequent innovation prior to the emergence of *H. sapiens* was the appearance of essentially modern body form and proportions, about two million years ago. This event coincided more or less with the initiation of a prolonged radiation of hominid species showing on average brain/body size ratios significantly enlarging with time. Knowing what that factor was that consistently disposed hominids to acquire metabolically expensive larger brains after the early initiation of this trend

will be critical to discovering exactly what it was that eventually made us the truly unique creatures we are today. But it nonetheless remains true that the two most fateful and unprecedented innovations in hominid history—one cognitive, one economic—were remarkably recent, both appearing on Earth well *within* the lifetime of our species, *H. sapiens*.

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