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ORIGINAL PAPER

Human evolution and cognition

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Abstract Human beings are distinguished from all other organisms by their symbolic way of processing information about the world. This unique cognitive style is qualitatively different from all the earlier hominid cognitive styles, and is not simply an improved version of them. The hominid fossil and archaeological records show clearly that biological and technological innovations have typically been highly sporadic, and totally out of phase, since the invention of stone tools some 2.5 million years ago. They also confirm that this pattern applied in the arrival of modern cognition: the anatomically recognizable species *Homo sapiens* was well established long before any population of it began to show indications of behaving symbolically. This places the origin of symbolic thought in the realms of exaptation, whereby new structures come into existence before being recruited to new uses, and of emergence, whereby entire new levels of complexity are achieved through new combinations of attributes unremarkable in themselves. Both these phenomena involve entirely routine evolutionary processes; special as we human beings may consider ourselves, there was nothing special about the way we came into existence. Modern human cognition is a very recent acquisition; and its emergence ushered in an entirely new pattern of technological (and other behavioral) innovation, in which constant change results from the ceaseless exploration of the potential inherent in our new capacity.

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Introduction: cognition in humans and apes

Human beings are distinguished in many ways from their relatively small-brained, large-faced, quadrupedal, arboreal, knuckle-walking closest living relatives, the great apes. Yet undoubtedly, what gives us such a strong feeling of *difference* from them, and indeed from all other sensate things, is the remarkable way in which we process information about the world around us. Uniquely, as far as we know, we mentally dissect our animate and inanimate surroundings into a mass of intangible symbols that we can recombine to produce new images of the world as it is and as it might be, and as a result, we live at least partly in worlds of our own intellectual creation, rather than in the world as Nature presents it to us.

Our comprehension of ourselves and of our lives is mediated by ratiocinative as well as intuitive processes. Of course, some great apes, at least, are adept users of symbols in experimental situations (Savage-Rumbaugh 1994). However, they do not manipulate those symbols in such a way as to re-create the world. In general, the apes' use of symbols seems to be additive: they can comprehend short strings of notions ("take," "red," "ball," "outside"), but they do not recombine them according to mental rules to produce new concepts: ideas of the possible, rather than of the observed. The chimpanzee manner of dealing with symbols is thus inherently limited, since lengthening series of symbols rapidly become confusing, and ultimately meaningless.

Daniel Povinelli, a distinguished researcher of chimpanzee cognition, has recently proposed (Povinelli 2004) that a fundamental distinction between the ways in which chimpanzees and humans view the world is that, while humans form abstract views about other individuals and their motivations, “chimpanzees rely strictly upon observable features of others to forge their social concepts. If correct, [this] would mean that chimpanzees do not realize that there is more to others than their movements, facial expressions, and habits of behavior. They would not understand that other beings are repositories of private, internal experience” (Povinelli 2004, p. 33). Further, it would also imply that individual chimpanzees do not have such awareness of themselves, either. They *experience* the emotions and intuitions that arise in their own minds; and they may act on them, or suppress them, as the situation demands or permits. However, they “do not reason about what others think, believe and feel—precisely because they do not form such concepts in the first place” (Povinelli 2004, p. 33).

Profound as it may be, this cognitive difference between chimpanzees and humans may not always produce radically distinctive observable behaviors; and indeed, the ways in which apes and humans behave sometimes appear, at least superficially, to be strikingly similar (e.g., de Waal 1998). Still, we should be wary of overstating such resemblances. The behavioral likenesses we perceive are readily explained by an enormously long-shared evolutionary history and the resulting structural similarities; but as Povinelli would doubtless point out, similar observable behaviors may also hide mental processes that differ greatly in form and complexity.

Therefore, despite the fact that hardly a day passes during which it is not announced that an ape does something that we once thought only we did (perhaps most spectacularly, spear-hunting by chimpanzees: Pruetz and Bertolani 2007), the cognitive gulf still yawns. Still, even though there has doubtless been a lot of evolutionary water of one kind or another under the bridge on both sides since human beings shared an ancestor with any ape, most authorities find it reasonable to conclude that cognition of the kind we see among chimpanzees (and, generally speaking, among other great apes too) provides us with a reasonable approximation of the cognitive point from which our ancestors started some 7 million years ago. In Povinelli’s (2004, p. 34) words, one may reasonably assume that those ancestors were “intelligent, thinking creatures who deftly attend[ed] to and learn[ed] about the regularities that unfold[ed] in the world around them. However, … they [did] not reason about unobservable things: they [had] no ideas about the ‘mind,’ no notion of ‘causation.’” In the human sense, they had as yet no idea of self. This is a very plausible characterization of our lineage’s starting point, and at the same time it exhausts what can usefully be said on this subject based on existing studies of comparative cognition. If we wish to know how our lineage achieved its current cognitive state from a starting point similar to that characterized by Povinelli, then we need to turn to our fossil and archaeological records.

The human fossil record

All fossil primates believed to be more closely related to us than to any of the extant apes are grouped together into the family Hominidae (or the subfamily Homininae, or whatever: the exact terminology is of no consequence here). Figure 1 is a highly provisional hominid tree that summarizes the diversity, if not well-resolved relationships, within the family. Early hominids known from the period between about 7 and 4 million years (myr) ago are mostly fragmentary, and they are an oddly assorted group (for references and more detail on this and other aspects of the human fossil record, see Tattersall 2009 and the recent Special Issue of *Science* [vol 326, no. 5949, 2009] devoted to *Ardipithecus*). Indeed the main message they bequeath us is that, from the very start, the history of Hominidae has been one of vigorous evolutionary experimentation with the evidently many ways there are in which to be a hominid. Mainly, what all these forms have in common is that all are claimed to have been upright bipeds when moving on the ground. This unusual locomotor pattern was presumably adopted in consequence of the drying-out and increasing seasonality of the African climate following around 10 million years ago. This led to the gradual fragmentation of the continent’s formerly monolithic forests, and to the widespread occurrence, initially, of forest fringe and woodland habitats. This environmental change forced the ancestral hominids out of the ancestral deep forests and into more open habitats where they were obliged to spend increasing amounts of time on the ground. Why they opted to move bipedally on the new substrate has been the subject of much discussion, but it is inconceivable that they would have done it had it not been the most natural way for them to get around. This implies that the arboreal ancestors of hominids had already habitually held their trunks upright while moving around in the trees (perhaps significantly, *Ardipithecus* is said not to have: Lovejoy et al. 2009), and it contrasts with what we see in modern great apes. These mostly move quadrupedally on the ground, using specialized mechanisms of the wrist to bear the weight of the foreparts on folded knuckles—thereby conserving the arboreal grasping abilities of the long-fingered hands.

The hominid fossil record improves following about 4 million years ago, when we begin to find the first

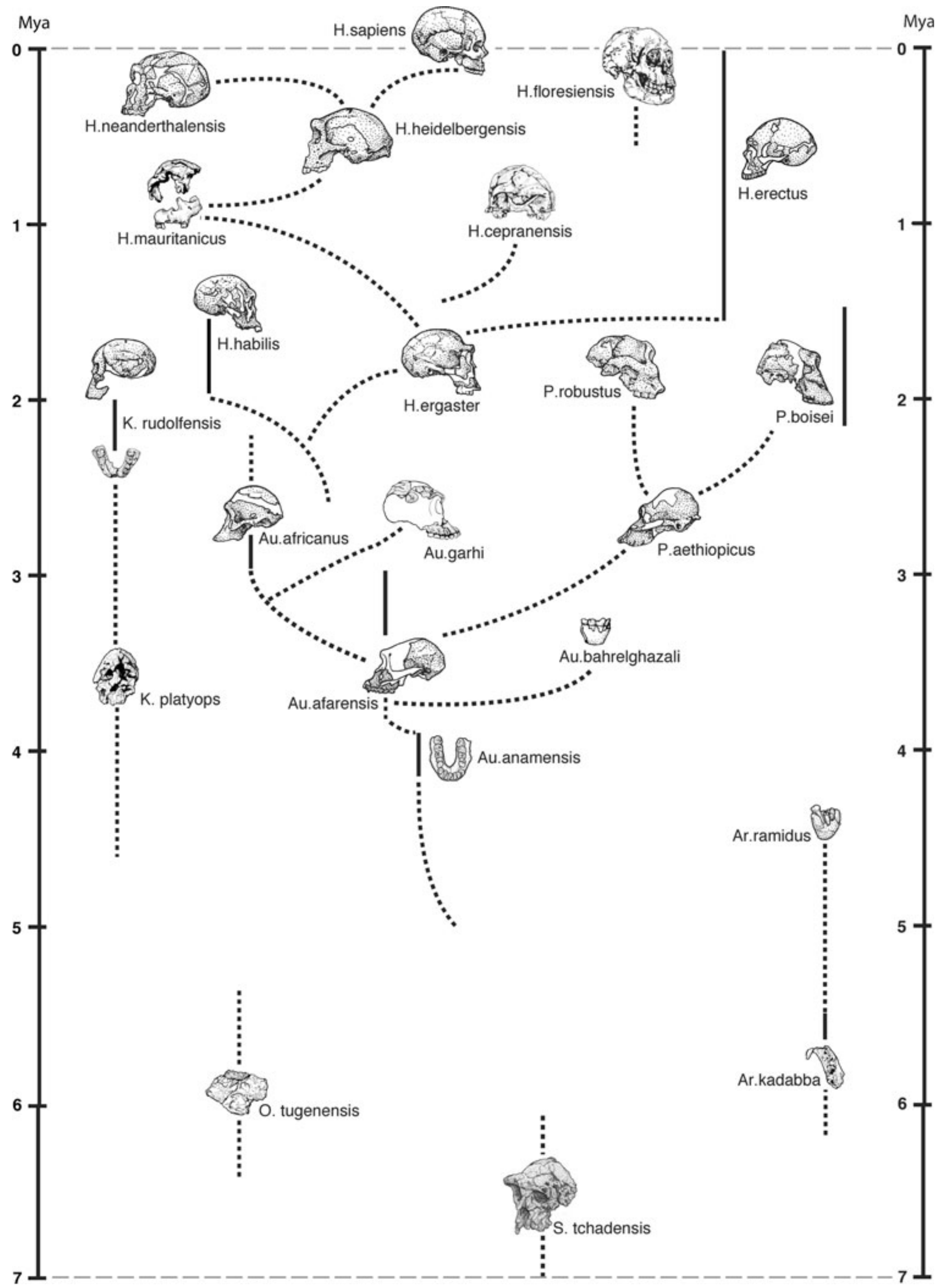

Fig. 1 Highly tentative phylogeny of the hominid family, showing the diversity of species currently known within the group and indicating some possible lines of descent. © Ian Tattersall

members of the genus *Australopithecus* in eastern Africa. The best known species of this genus is *Australopithecus afarensis*, most famously known from the fossil known as "Lucy": a partial skeleton of an individual, believed to be a young adult female, who died some 3.2 myr ago. With a stratigraphic range of about 3.8–3.0 myr ago, *A. afarensis* shows clear adaptations to upright bipedality in its leg and pelvis structure, though it retains adaptations to climbing in its upper body structure and extremities. Males seem to have been substantially larger than females, although the implications of this for social structure remain unclear. More significant may be that these small-bodied primates were vulnerable in their new habitat and may well have exhibited the characteristics of a prey species (Hart and Sussman 2005), in which case they probably lived in large social groups with multiple adults of each sex and complex systems of social relationships.

For all of its new locomotor adaptations, though, *A. afarensis* showed none of the later hominid tendency toward brain size increase. With ape-sized brains lodged in small braincases that lay behind protruding faces that contained long toothrows (though substantially reduced canine teeth), early hominids of this general kind ("australopiths") are often referred to as "bipedal apes." Certainly, there is little to suggest that they exhibited any cognitive advance relative to what we can observe today in great apes (studies of brain endocasts remain at best equivocal on this matter); and Povinelli's assessment of the hypothetical hominid ancestor, quoted earlier, would seem quite reasonably applied to these early fossil forms.

The first stone tools

Remarkably, however, the earliest stone tools were almost certainly invented by creatures that we could otherwise characterize as "bipedal apes." At around 2.5 myr ago, when no other kinds of hominids were on the scene, we first begin to pick up evidence of the manufacture of stone implements at sites in Ethiopia and Kenya. These tools were simple, principally consisting of sharp-edged flakes chipped from a stone "core" using a stone "hammer." However, the ability to strike one stone with another at precisely the force and angle necessary to detach a sharp flake lies beyond what any modern ape has been able to achieve, even with intensive coaching (Schick and Toth 1993; Schick et al. 1999). What is more, the early stone tool makers showed remarkable foresight, again out of the ape league, in carrying suitable materials with them for considerable distances until making them into tools as needed (Klein 1999). The tools were used to butcher the carcasses of medium-sized or even large mammals, though there is no way to know how the hominids obtained those carcasses (which would have been objects of great contention among open-country predators and scavengers). Clearly, such behaviors are witness to an increase in cognitive complexity among the toolmakers relative to their precursors, though sadly we have no way of knowing how this may have reflected itself in other aspects of their economic or social lives, or in the ways in which they perceived the world around them.

The manufacture of stone tools by bipedal apes inaugurates a pattern of innovation that we subsequently see consistently repeated in the hominid record: biological and cultural innovations in that record are out of phase. In no case can we use the arrival of a new kind of hominid to "explain" the appearance of a new technology. This actually makes pretty good sense, since any cultural innovation must be made by an individual—who has to belong to a pre-existing species. What is more, such innovation must capitalize on a potential that is already somehow present within that species: after all, necessity cannot call that potential into existence. There is, indeed, a case to be made that all new capacities come into existence initially as *ex*aptations rather than as *ad*aptations, i.e., independently of the uses to which they may later be put. Structure must precede function, if only because without structure there can be no function.

The second major pattern of innovation in the hominid cultural record was also established earlier on. For a million years after the first stone tools were made, tool making methods changed little. Stone cores from which flakes had been detached were used for pounding, especially in cracking bones to access the marrow, producing characteristic "torsional" fractures; and the flakes themselves were routinely used for dismembering carcasses (Schick and Toth 1993). However, no radical improvements in this technology were made until about 1.5 million years ago, when the first "handaxes" appear at African sites (Klein 1999). These larger tools were carefully shaped, with multiple blows to both sides, to produce implements of a standard shape. It had not previously mattered what a stone flake looked like; all that was important was the sharp edge. In contrast, the teardrop-shaped handaxe was clearly made to a "mental template" that existed in the toolmaker's mind before knapping started (Schick and Toth 1993). Here again, we see evidence of a cognitive advance of some kind; yet this advance was only expressed several hundred thousand years *after* a new kind of hominid came on the scene.

Best known from the amazingly preserved "Turkana Boy" skeleton from northern Kenya, this new kind of hominid, *Homo ergaster*, was the first to be of essentially modern body size and build. The Turkana Boy skeleton is that of an adolescent who had died some 1.6 myr ago at the age of eight, when he was already some 164 cm. tall. Had he lived to maturity, however, he would have grown to over 187 cm. His limbs were long and slender, and his body form was well adapted to the hot, shadeless savannas that were now beginning to dominate the environment in which he lived (Walker and Leakey 1993). Here at last was a hominid that was emancipated from the forest edges and woodlands to which its precursors had been confined: a long-distance walker and runner, slow but with stamina and endurance. This change portended a new way of predatory life, but there is no way of knowing if this new potential was yet exploited. Maybe not, indeed, since hominids presumed to have had this kind of postcranial adaptation are known from around 1.9 million years ago, when new technologies still lay far in the future. Still, another recurrent pattern in hominid history has been that—until very recently, as we'll see, hominids always tended to respond to environmental change by using old technologies in new ways, rather than by introducing new ones.

Below the neck the fossils of *Homo ergaster* differ from their modern human counterparts in a variety of mostly minor ways. However, the cranial differences are substantial, even though portents of what was to come are more striking than features harking back to the past. The brain cavity of the Turkana Boy is, for example, modestly larger than was typical of the bipedal apes Walker and Leakey 1993). These latter had brains approximately one-third of the size of modern humans, while that of the Boy was slightly over half. In this we see the inauguration, after 5 million years of flatlining, the trend toward increasing brain size that has independently characterized several different lineages of hominids ever since. To summarize: 2 million years ago, hominid brains were ape-sized. A million years later, they had doubled in size; and today they are twice as large again. This trend is independently seen in the lineages that ultimately resulted in *Homo sapiens*, *Homo neanderthalensis*, and the latest *Homo erectus*. Exactly what it was about earlier species of our genus *Homo* that predisposed them toward metabolically expensive larger brains remains unknown, although many observers favor some kind of hypothetical feedback mechanism between larger brains and increasing social complexity. Still, at present this is conjecture; and knowing exactly how this predisposition to brain enlargement was underwritten biologically will be crucial in understanding how humans came to be the cognitively unique creatures they are today. Sadly, studies of the external morphologies of the brains of fossil hominid have proven rather unilluminating in this regard (see discussion by Holloway et al. 2004). What is already clear, however, is that the trend toward increasing brain size in the later phases of human evolution did not take place in the context of the intellectual burnishing of a single central lineage, but rather in that of the preferential survival over time of larger-brained species (Tattersall 2008).

Out of Africa

Hard on the heels of the acquisition of modern human body form, we find the first hominids outside Africa. Best documented at the Georgian site of Dmanisi, these émigrés had neither larger brains nor better technologies than the hominids had who stayed behind, and the key to their mobility must have lain either in the new body form (although the Dmanisi hominids seem to have been pretty diminutive, see Lordkipanidze et al. 2007) or in new ecological opportunities as Eurasian habitats changed. Hand-axes are not seen in Asia (Hou et al. 2000) or Europe (Scott and Gibert 2009) until around a million years ago; and even then they did not catch on like wildfire, as one might have expected any truly advantageous new technology to do. Once again, the pattern seems one of resistance to change, rather than of embracing it. The same might be said of the domestication of fire. This revolutionary innovation must have made a huge difference to hominid life, affording not only protection from predators but the ability to render previously indigestible foods nutritionally available. Thick layers of ash at a site in Israel now establish that fire was initially domesticated by about 800 thousand (kyr) ago (Goren-Inbar et al. 2004); but the control of fires in hearths only appears to have gained in frequency since about 400 kyr ago (Klein 1999), and routine only long after that.

Early excursions out of Africa seem to have led to the establishment of the species *Homo erectus* in eastern Asia by as early as 1.6 myr ago, or perhaps more (Swisher III et al. 1994), and hominid fossils of uncertain affinities are now known in Europe as early as 1.2 myr or more (Carbonell et al. 2008). However, the first truly cosmopolitan hominid species was *Homo heidelbergensis*, known first in Ethiopia at about 600 kyr ago. It was within the tenure of this species that the control of fire became common, that the first shelters were built (de Lumley and Boone 1976) and that the first (miraculously preserved) wooden spears are known, from the German site of Schoeningen (Thieme 1997). These spears are balanced like throwing instruments, and appear to have been missiles, in which case ambush-hunting techniques might have been more advanced at this period than might have been guessed from the lithic record alone.

It was also during the time of *Homo heidelbergensis* that the next conceptual advance was made in stone tool manufacture. This was the "prepared-core" tool, made by shaping a stone core until a single blow would detach a more or less finished tool of predetermined shape, with a continuous sharp edge all around its periphery (Klein 1999). Ultimately, such flake tools seem to have been quite routinely hafted to form complex implements. *Homo heidelbergensis* is known by African, European, and Chinese fossils dating from about 600 kyr ago until (perhaps) 200 kyr ago, a period during which technological innovations seem to have accumulated in an episodic manner. Members of this species possessed brains that lay well within the modern size range, though below the modern average; and it may be that in a very broad sense *Homo heidelbergensis* was the progenitor, over half a million years ago, of the lineages that led in Africa to the earliest *Homo sapiens* and, in Europe, to the endemic lineage that eventuated in *Homo neanderthalensis* (Tattersall and Schwartz 2009).

The Neanderthals are particularly interesting to us because they are incomparably better documented than any other extinct hominid species, and because they had brains at least as large as our own. They thus provide the best yardstick we have by which to measure our own uniqueness. Physically, *Homo neanderthalensis* was extremely distinctive, with a skull of hugely different construction to ours, a funnel-shaped rib cage that flared to meet a very wide pelvis, and thick-walled long bones with large articular surfaces. These hominids flourished in Ice Age environments that were sometimes extremely difficult, and they seem to have established themselves as the apex predators in an array of habitats that frequently offered hominids little sustenance besides what could be supplied by other animals. They were perhaps the most skillful practitioners ever of the prepared-core stoneworking method, and were clearly intelligent and resourceful (Klein 1999). However, although skilled craftsmen, Neanderthals were not inventive: there was a monotony to their stone tool kit over the entire huge expanse of space and time that they occupied. And intelligent as they undoubtedly were, there is no good evidence supporting that they, or indeed any earlier hominids, were symbolic.

Of course, recognizing the material products of symbolic mental processes is not easy, and symbolic minds may produce nothing durable. Nonetheless, there is a good argument to be made that symbolic mental processes in extinct hominids are impossible to establish in the absence of overtly symbolic artifacts, and very few Paleolithic technologies indeed by themselves furnish evidence of symbolic mental processes on the part of their makers. Intuitive, nonsymbolic, nondeclarative forms of intelligence are evidently capable of producing substantial results; and we may fairly take the very impressive material products of the Neanderthals as very probably the ultimate in what purely intuitive minds can accomplish. However, it is probably more realistic to view the Neanderthals as the most sophisticated expression of the intellectual style that had preceded them, than to see them as anticipating the symbolic mental processes that were to come.

The dual origin of modern humans

Modern human bony anatomy is very distinctive, and it is essentially unanticipated in the fossil record. The Neanderthals have identifiably close relatives in the fossil record; *Homo sapiens* does not. Possibly we are looking here at an artifact of preservation or geological sampling; but it is also very possible that, as an anatomical entity, our species was born in a short-term change of gene regulation that was small in structural terms, but that had hugely ramifying developmental consequences throughout the body. The very earliest fossils that bear the distinctive morphological stamp of *Homo sapiens*, or something very like it, come from sites in Ethiopia that are dated to 195 and 160 kyr ago (McDougall et al. 2005; White et al. 2003). Several other putative early *Homo sapiens* are known in Africa (evidently the continent of origin of our species) over the following several tens of millennia; and by 93 kyr ago (Valladas et al. 1988) fully modern human cranial anatomy is documented outside Africa, in the Levant.

The early African *Homo sapiens* are associated with unremarkable or even archaic stone tool kits (Klein 1999), while the early Levantine moderns are associated with lithic industries that are undistinguishable from those being made in the same area by penecontemporaneous Neanderthals. Certainly, there is nothing in the record of either species at this point of time to suggest that their behavioral repertoires were significantly different, and there is no substantive evidence of symbolic mental processes in either case.

The very first unequivocal stirrings of the human symbolic spirit are found in Africa, at sites postdating 100 kyr. A modern symbolic division of living spaces has been reported from sites of about that age at Klasies River Mouth, near Africa's southern tip (Deacon and Deacon 1999); but for material objects that bear witness to symbolic mental processes on the part of their makers the wait is longer. At Blombos Cave, not far away, 77-kyr-old occupation layers have yielded a couple of engraved ochre plaques, one with a bold geometric design, that certainly seem to offer prima facie evidence of a symbolic consciousness at work (Henshilwood et al. 2003). Adjacent layers at the same site have produced invertebrate shells that were apparently pierced for stringing into bodily ornaments (Henshilwood et al. 2004). Such ornamentation has had strongly symbolic overtones in every human society ever studied, and similar "beads" of about the same age or even earlier have now been reported at a site in northern Africa, and even in at one in the Levant (Bouzzougar et al. 2007; Vanhaeren et al. 2006). The symbolic manifestations at Blombos were found in a Middle Stone Age context, roughly equivalent to the Middle Paleolithic of the Neanderthals but more complex in certain respects. The most striking such complexity is the heat-treatment of silcrete recently reported from 72-kyr levels, and even earlier, at the nearby cave of Pinnacle point (Brown et al. 2009). This was a multi-stage process that almost certainly demanded symbolic cognition on the part of its practitioners, and furnishes us with perhaps the only thoroughly satisfactory technological evidence of symbolic thought that we have from before the Upper Paleolithic in Europe, over 40 kyr later.

Since about 70 kyr ago, southern Africa witnessed a substantial period of drought, and there is some doubt over whether these early symbolic expressions were linearly antecedent to later ones. Indeed, molecular systematists reckon that the population of *Homo sapiens* underwent a severe "bottlenecking," in which it was reduced to a few thousand or even a few hundred individuals (Fagundes et al. 2007). Small populations are, of course, more conducive than larger ones are to the fixation of novelties, whether in the form of new genes or new ways of doing things; and the environmental exigencies that squeezed the human population certainly produced ideal circumstances for the establishment of entirely novel ways of doing business. In any event, the molecular record indicates that, once the population crisis was past, *Homo sapiens* populations began to burgeon again, and to spread beyond Africa to populate the entire Old World within a remarkably short window of time.

One such exodus ultimately wound up in Europe, which was reached by about 40 kyr ago; and it is this group of *Homo sapiens* that has bequeathed to us the most spectacular material evidence for the unique creative human spirit that doubtless resided in all of the emigrant groups, and among their conspecifics who stayed at home in Africa (Klein 1999). The flourishing of artistic activity among the Ice Age Europeans of $\leq$40 to $\sim$10 kyr ago is nothing short of astonishing. Extending well beyond cave painting and carving, to systems of notation and the manufacture of sophisticated musical instruments, the Ice Age cultures of Europe produced some of the most powerful, deftly drawn and closely observed images that have ever been produced (see Clottes 2008): the most overwhelming imaginable evidence of the modern symbolic sensibility. Truly, however different culturally and linguistically they may have been, these people were *us* in the most profound of senses.

These were also the people who, in less than 10 millennia, managed to eliminate the formidable Neanderthals from the entire vast territory they had formerly inhabited, edging them into extinction and in the contrast between the two hominid species, we see most closely mirrored the image of just what it is that makes us unique.

The Neanderthals were, as far as we can tell, essentially non-symbolic, while the lives of the newcomers were drenched in symbol. The most crucial difference lay in the human symbolic mental manipulation of information about the world: a process that made possible not only planning for activities that had been performed in the past, but planning for activities that had never been undertaken before. This had huge demographic consequences, which in the event have driven human history ever since. Neanderthals were evidently thinly spread over the landscape, making a fairly meager living in what were mostly very difficult environments. Early European *Homo sapiens*, on the other hand, appear to have lived in much larger densities, and at least seasonally in much larger and almost certainly socially much more complex groups. They needed territory in a way in which no other hominids had ever done before.

In any event, by about 40 kyr ago we have abundant evidence of the arrival of the modern human spirit. Yet the very earliest hominids who looked exactly as we do—who had brains that were externally identical to ours, and who had perfectly modern vocal tracts—apparently behaved pretty much as the Neanderthals did. There was evidently a lag of perhaps a hundred thousand years between the acquisition of modern anatomical form and the first stirrings of modern behavioral expression.

At first, this might seem a little odd. If you had the potential to behave like a modern person, why wouldn't you? Well, it may not seem so odd if you think of the typical pattern of innovation we have already established in the hominid fossil record, whereby new biological arrivals on the scene never immediately behaved in new ways. New behavioral potentials often need to be *discovered* by their possessors; and, as already noted, a good argument can be made that innovations necessarily arise as *ex*aptations, rather than as *adaptations*, and, structure necessarily precedes function. Exaptation is a routine phenomenon in evolution, and many major "transitions" would have been impossible in its absence. Tetrapods gained their limbs while they were still full-time aquatic forms; and the ancestors of birds had feathers millions of years before co-opting them for flight.

In this perspective, there is nothing unremarkable about the acquisition of symbolic cognition by *Homo sapiens.* This is so even though our unique mode of processing information is clearly not in the least a simple extrapolation of the evolutionary trend to enlarging brain size (and presumably of the increasing "intelligence" that accompanied it). Ours is intelligence of an entirely new kind. It is an "emergent" acquisition, whereby a simple addition to a pre-existing structure produced an entirely new level of complexity, much as the addition of the keystone to an arch produces a structure that is radically more than the simple sum of its components. Of course, our extraordinary cognitive style would not have been possible without any of the many accretionary acquisitions that had been made in the human lineage over hundreds of millions of years of vertebrate brain evolution. However, it was not *predicted* by the trends that preceded it (Tattersall 2008).

The neural structure that underwrites symbolic mental processes was thus evidently acquired in an entirely adventitious fashion. Clearly, whatever the biological innovation was, it resulted in a backwardly compatible brain that was able to do business exactly as its ancestors' brains had done. Moreover, its new potential lay fallow for several tens of thousands of years, at least, until that potential was "discovered" through the action of what must necessarily have been a cultural stimulus. What this cultural stimulus was has been the subject of a lot of speculation, if usually in the context of a natural-selection-driven notion of the origins of consciousness. One top contender involves levels of intentionality (Dunbar 1996): the increasingly sophisticated reading of the minds of other individuals, driven by the possibilities of social/

reproductive success. The ability to understand chains of intentionality is, however, an internalized quality, one that would have been less readily spread through the population (indeed, that might, with advantage, have been hidden by its possessor) than some more communal attribute might have been. The most obvious such communal attribute is language, which is at the same time the ultimate symbolic phenomenon (Hauser et al. 2002). Today, language is virtually inseparable from symbolic thought, involving as it does the creation of intangible symbols that can be combined and then recombined according to basic rules, to ask questions such as "what if?" I, for one, find it hard to conceive of symbolic thought in its absence. Further, we have to bear in mind that once the modern anatomical structure was in existence, all of the apparatus was obviously already there that ultimately permitted the production of the sounds associated with articulate speech.

Conclusion

At first glance, the gap between a non-symbolic, non-linguistic ancestor and a symbolic, linguistic descendant seems virtually unbridgeable. Certainly, the latter is not a simple extrapolation of, or improvement on, the former. Indeed, the *only* reason for thinking that such a transition *could* be made, is that it *was* made. There can be no doubt that at some remove *Homo sapiens* possessed ancestors that did not process or communicate information in the way that it does. Those ancestors doubtless had highly sophisticated forms of both gestural and vocal communication, but these almost certainly differed qualitatively from the communicative styles we have today, as did the underlying cognitive pattern underwriting them. Qualitative jumps are invariably hard to explain by the slow workings of natural selection, and other mechanisms have to be sought. In trying to understand the evolution of the unique human style of cognition, a combination of exaptation and emergence seems to fit the situation perfectly; and if this was the case, special as we see ourselves, our appearance was perfectly routine in evolutionary terms.

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