doi 10.4436/jass.94030

JASs Proceeding Paper

Journal of Anthropological Sciences
Vol. 94 (2016), pp. 157-166

A tentative framework for the acquisition of language and modern human cognition

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Summary - *Modern human beings process information symbolically, rearranging mental symbols to envision multiple potential realities. They also express the ideas they form using structured articulate language. No other living creature does either of these things. Yet it is evident that we are descended from a non-symbolic and non-linguistic ancestor. How did this astonishing transformation occur? Scrutiny of the fossil and archaeological records reveals that the transition to symbolic reasoning happened very late in hominid history – indeed, within the tenure of anatomically recognizable* Homo sapiens. *It was evidently not simply a passive result of the increase in brain size that typified multiple lineages of the genus* Homo *over the Pleistocene. Instead, a brain exaptively capable of complex symbolic manipulation and language acquisition was acquired in the major developmental reorganization that gave rise to the anatomically distinctive species* Homo sapiens. *The new capacity it conferred was later recruited through the action of a cultural stimulus, most plausibly the spontaneous invention of language.*

Keywords - *Human evolution,* Homo sapiens*, Symbolic cognition, Language, Speech.*

Introduction

We modern *Homo sapiens* have many unusual attributes. But nothing about us is more unusual than the manner in which we process information. The key to the cognitive difference between us and even our closest living relatives, is that we human beings think symbolically. We deconstruct our exterior and interior worlds into vocabularies of discrete mental symbols that can be rearranged to produce alternate perspectives and to envision new possibilities, even about the unobservable. Closely tied to this capacity is structured articulate language, which we use to express, to communicate, and at least in part to generate our ideas (Bolhuis *et al.*, 2014).

None of this, of course, implies that among primates and various other vertebrates, both cognition and vocal communication cannot be very complex indeed. However, compared to modern human beings, all other organisms – including even very close and very cognitively complex human relatives such as chimpanzees and bonobos – deal with information in a relatively straightforward manner. Great apes can recognize symbols, and can even use them additively, to make and understand simple statements. But the additive algorithm is limited, and does not engender multiple alternatives. As a result, there is a narrow but hugely significant gulf between the cognitive styles of apes and human beings.

This having been said, there is no doubt that our symbolic, linguistic species is descended from an ancestor that was neither of these things. So, at some point, that cognitive and linguistic gulf must have been bridged. Understanding just how this was accomplished is perhaps the trickiest enterprise in all paleoanthropology, not least because the process by which we became human has profound implications for our very identity. If we achieved our cognitive style gradually, under the consistent pressures of natural selection, then it would be reasonable to conclude that we have in some way been molded by Nature to be the kind of creature we are. But if our unique mode of processing information was somehow adventitiously acquired, then the conclusion would be radically different.

Recognizing behavioral complexity

Teasing out the details of hominid cognitive evolution from available evidence is difficult, due less to the quantity of available evidence than its quality. Humans have a more abundant and diverse fossil record than is than often appreciated. But even where they are well preserved, mineralized crania have proven limited in what they can tell us about past cognition. Thus the unusual behaviors associated with symbolic thought are not correlated in any useful way with brain mass, while the paleoneurologists can find little to agree on in preserved external brain morphology. And although we have tangible, if spotty, evidence of the presence or absence of bony conformations putatively associated with speech, the anatomical potential to produce speech is far from synonymous with the possession of structured language (Tattersall, 2008; Bolhuis *et al*., 2014). The same also applies to the physical ability to hear sounds within the frequency range of modern speech, something recently demonstrated for the Neanderthal-clade Atapuerca hominids (Martinez *et al*., 2012).

Fortunately, over the past 2.5 million years the fossil record is supplemented by an archaeological record storing information about past hominid behaviors. For most of the Pleistocene this register consists mostly of stone tools and butchered animal bones, and how they are disposed at occupation sites and across landscapes. Sadly, such information is limited in what it reveals about how our precursors subjectively perceived and processed information about the world; for while it may reflect general complexities of lifestyle, it is a poor proxy for cognitive condition. In this realm it tells us mainly that you can be very complex and intelligent indeed, without exhibiting the exact cognitive style of *Homo sapiens.*

This is challenging for paleoanthropologists who are, naturally enough, bound by the parameters of their own human cognition, and thus find it difficult to imagine what it would be like to possess a sophisticated perception of the world unlike their own. Too often, the default is to look at extinct hominids simply as less capable versions of ourselves. Yet doing this involves denying our vanished relatives their due as creatures who experienced the world in their own distinctive ways, even as it distorts our views of our own origins. Every extinct hominid species had its own cognitive identity, just as we do ours.

Complicating the difficult matter of cognition among extinct hominids is wild variation in scientists' interpretation of putative proxies for language and symbolic thought. The highly selectionist evolutionary psychologists (e.g. Tooby & Cosmides, 2000) have supposed that hominids gradually accumulated linguistic abilities in a feedback process between brain and behavior spanning the Pleistocene epoch, basically, the entire period over which hominid brains on average enlarged with time, following an initial several million years of flatlining. Paleoanthropologists and neurobiologists have differed on this issue, but like the evolutionary psychologists many have also favored an early origin of language in some form (Tobias, 1995). On the linguistics side, some believe that "true language, via the emergence of syntax, was a catastrophic event, occurring within the first few generations of *Homo sapiens sapiens*" (Bickerton, 1995, p. 69), a conclusion later echoed by Fitch, Hauser & Chomsky (2002). However, other linguists have claimed the opposite: "Language evolved over millions of years" (Lieberman, 2015, p. 1).

This vast range of opinion exists, of course, because language is an intangible that fails to preserve directly and is not closely correlated with anything that does. Similarly, symbolic thought is barely easier to approach in material terms, because we are obliged to make indirect inferences about anything except for explicitly technological behaviors. And these latter pose their own difficulties, for while many Paleolithic stone-working techniques certainly reflect very acute states of awareness, few if any can be used in isolation to infer specifically modern human cognition. One possible exception is the heat treatment of silcrete documented at South African sites as far back as 75 kyr (and conceivably to 160 kyr: Brown *et al.*, 2009). But while this complex multi-stage process bears witness to high cognitive sophistication among the early *Homo sapiens* who wielded it, it cannot definitively be said to implicate symbolic cognition. On the limiting assumption that the only way to be very highly intelligent is our own way, it is tempting to conclude that it does; but if we concede that early hominids could be very smart indeed without necessarily being *us*, we have to recognize the limitations of inference based on technological prowess alone, at least at Paleolithic levels.

Such limitations may well confine us to explicitly symbolic artifacts as reliable proxies for modern symbolic cognition. But context nonetheless remains key. A recent report describes a mollusk shell from the type locality of *Homo erectus* in Java. Dated to around 0.5 myr, this was apparently deliberately engraved with a pattern of zigzag lines. At another time and place, an object like this would be assumed symbolic; but in the absence of any larger symbolic context for *Homo erectus*, the authors wisely conclude only that “engraving abstract patterns was in the realm of Asian *Homo erectus* cognition and neuromotor control” (Joordens *et al.*, 2015, p. 228). Similarly, while the roughly-altered lump of stone from the >230 kyr site of Berekhat Ram in Israel initially reported as an anthropomorphic figure (Goren-Inbar, 1986) has been both disputed (Mithen, 1999) and affirmed (d’Errico & Nowell, 2000), it is likewise significant that no larger cultural context exists for this putatively symbolic piece. To conclude that a Middle Paleolithic individual was capable of modifying this object is not the same as to demonstrate that the society in which he or she lived depended on the symbolic capacity. This is important, because meaningful implementation of any new capacity or function can only have evolutionary significance in the context of an entire society, and eventually of an entire species.

What seems more robust is the assumption that, if we find evidence for symbolic cognition, we can also infer language. For language is our most intrinsically symbolic activity: indeed, it is virtually impossible to imagine either in isolation. Like thought, language involves forming and manipulating symbols in the mind, and symbolic reasoning of the human kind is almost inconceivable in its absence. Apes such as the famous bonobo Kanzi have become remarkably adept at communicating using symbols provided by experimenters (see Cohen, 2010), but they do not organize them according to a grammar affording the “discrete infinity” (e.g. Chomsky, 2000) that allows the generation of unlimited meanings from a finite vocabulary. What’s more, Hinzen (2012, p. 647) has noted that the “close connection between grammar and thought” was a consistent theme in early studies of generative grammar, and has given persuasive arguments on the linguistic side for reviving the view that language and thought are “not two independent domains of inquiry.” In other words, among modern humans language and thought are so closely intertwined that they appear functionally, if not conceptually, inseparable.

The hominid fossil and archaeological records

The larger patterns in human evolution, and by extension the processes involved in creating them, make a useful starting point in exploring the origins of any novelty, including symbolic cognition. Let’s start with the very bushy hominid genealogical tree in Figure 1, revealing that multiple hominid lineages have typically flourished in parallel, with as many as seven coexisting at one time. And that is just in the known record, which certainly underestimates by a large factor the actual diversity that was out there. Clearly, the hominid evolutionary story was one of diversity, just as would be expected for any successful and widely-distributed mammal family. What’s more, we are not looking here at a slow, steady process of selective fine-tuning, as

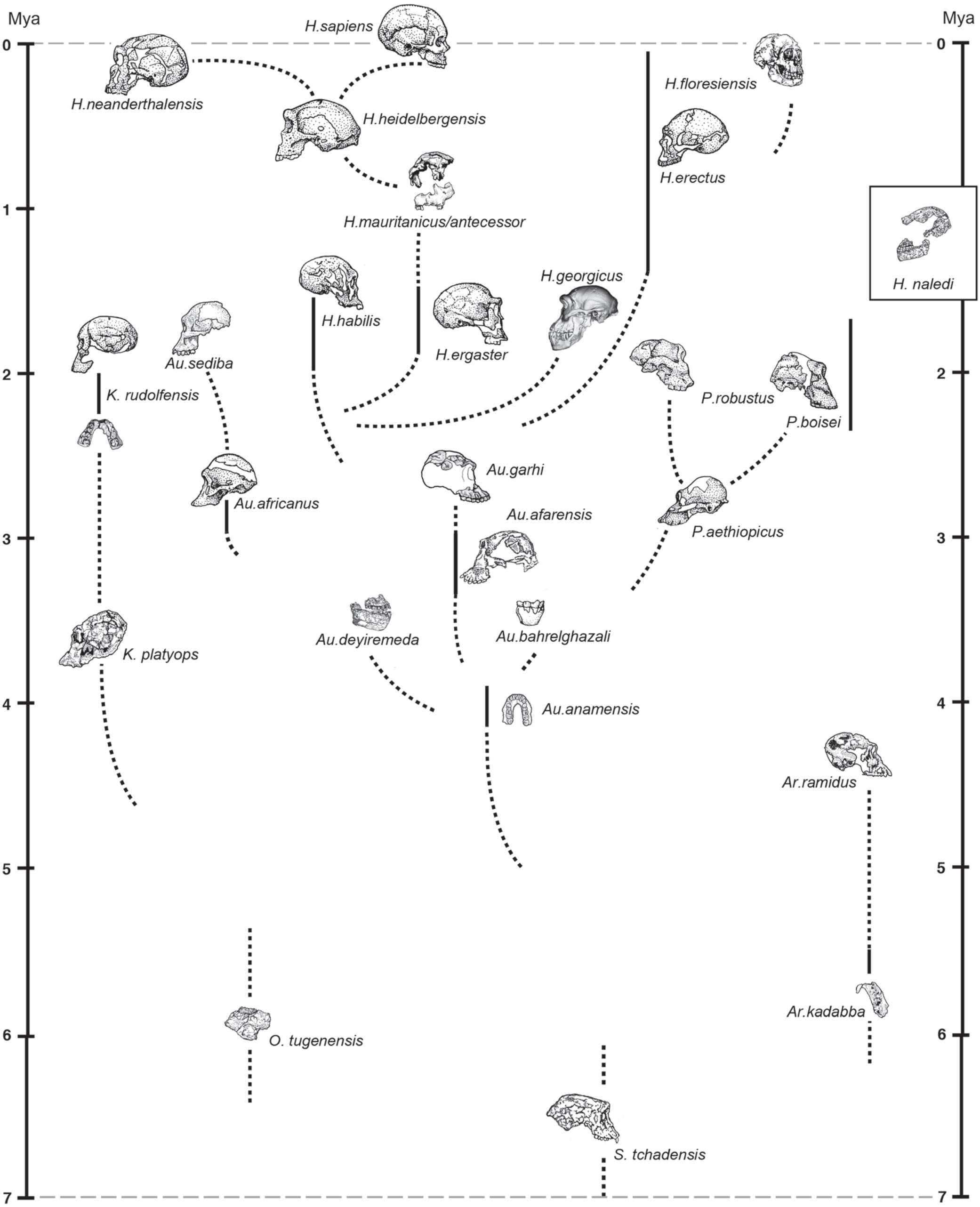

Fig. 1 – A tentative genealogical tree of the hominid family. Drawn by Jennifer Steffey.

fitter individuals simply out-reproduced less fit ones. Instead, what we see is a process of vigorous evolutionary experimentation, in which numerous variations on the hominid theme were tossed out to compete on the ecological stage. Against a climatic and environmental backdrop that is by now well established to have oscillated wildly on remarkably short time scales, some of those variants happened to do well, while most were triaged out. Equally important is the typically high diversity in our hominid family before the advent of *Homo sapiens*. The situation we take for granted today, with *Homo sapiens* as the only hominid species on the planet, is clearly extremely unusual. And this by itself suggests that there is something entirely unprecedented about our own species.

At the base of the tree, the most ancient claimed hominids present a rather miscellaneous and mostly poorly known assemblage. But insofar as they are documented, their brain to body size ratios appear generally to have been within the modern ape range; and, like the australopiths that immediately succeeded them, they seem generally to have merited description as "bipedal apes" (Aiello & Dean, 1990). Certainly, we have no substantial reason to believe that the earliest bipeds were significantly cognitively advanced relative to today's great apes. But by 2.5 million years ago, and possibly as early as 3.4 myr (Semaw *et al*., 1997; McPherron *et al*., 2010), the use and manufacture of sharp stone flakes for cutting indicates that archaically-proportioned and still small-brained early bipeds had acquired significantly advanced cognitive capacities, alongside substantially more eurytopic ecological strategies (Sponheimer & Lee-Thorp, 2015). By shortly after 2 myr ago, basically modern body proportions had been achieved, along with a commitment to the open savanna and all the changes in social and economic organization implied by this radical ecological shift. Brain size increase also began at this point. But, even with the introduction of the first deliberately-shaped stone tools following 1.78 myr ago (Lepre *et al*., 2011) – in itself emblematic of significantly increased cognitive complexity of some kind – the earliest members of *Homo* left no evidence of manipulating information symbolically.

The most ancient putatively symbolic object currently known is that modified 0.5 myr-old mussel shell from Java, which nevertheless remains a floating point bereft of larger cultural context. One swallow doesn't make a summer; and it seems significant that nothing remotely comparable is known until well beyond the introduction of prepared-core stone tools at around 300 kyr ago. This is not to say that there is no evidence for increasing cognitive complexity among Middle Pleistocene hominids. Exceptionally, long, narrow stone "blades" had been struck in Africa as far back as about half a million years ago; and in the 400-300 kyr interval fire domestication became a routine feature at archaeological sites (Roebroeks & Villa, 2011), and the first evidence is known of compound hafted tools, carefully-shaped long wooden throwing spears, and the construction of artificial shelters (Thieme, 1997; de Lumley, 1969). There was also soon to be that ambiguous figure from Berekhat Ram; and it is additionally true that on average hominid brain sizes had increased substantially by this time. But while early humans had evidently become significantly cleverer in their ways of dealing with the world, there is little reason to conclude that they were smarter in the specific modern human manner.

What seems to have been happening over this period is that the intuitive intelligence of hominids was increasing, along with brain size, most likely because larger-brained and cognitively more complex species were enjoying greater success in the struggle for ecological space (Tattersall, 2008, 2012) despite the high metabolic costs of larger brains. Still, the hominids concerned seem best regarded as incremental improvements over their predecessors, rather than as radical departures from earlier cognitive styles. Clearly, it was possible to be resourceful, smart, behaviorally flexible, and technologically sophisticated in the *absence* of symbolic reasoning, or at least of any culturally-established inclination to express this proclivity.

Something similar can even be said for *Homo neanderthalensis*, a large-brained species that evolved from indigenous European predecessors at about 200 kyr ago. The Neanderthals were wonderful craftsmen in stone, and left us an incomparable record of very complex lives. They flourished in an age of difficult climates, hunted some fearsomely large animals, and at least occasionally buried their dead. But they bequeathed us no convincing evidence of any consistent tradition of symbolic activity. The Neanderthal provenance of symbolic objects from the post-contact Châtelperronian tradition of Arcy-sur-Cure has been vigorously disputed (Bar Yosef & Bordes, 2010; Higham *et al.*, 2010), while the recently reported grid-like engraving from Gibraltar's Vanguard Cave (Rodriguez-Vidal *et al.*, 2014) is likewise very late, and bereft of clear context. Altogether, in a record as geographically, temporally, and materially as expansive as theirs, if the Neanderthals had routinely been symbolic thinkers it seems reasonable to suppose that they would have left more convincing indications of it. And what is probably most significant of all is the contrast between the essential cultural stasis of the Neanderthals and the radical change in the tempo of innovation that was ushered in by the first unarguable appearance of symbolic behaviors.

The origin of *Homo sapiens*

Remarkably enough, what can be said of the Neanderthals also applies to the earliest fossil *Homo sapiens*. These are found at sites in Ethiopia dating between about 200 and 160 kyr ago (McDougall *et al.*, 2005; White *et al.*, 2003), and they occur in association with notably archaic toolkits that include the very latest handaxes known from Africa (Clark *et al.*, 2003). And not until around 100 kyr ago do we start finding plausible indications that members of the new species were starting to think symbolically. At about this time, marine shell "beads" pierced for stringing, and sometimes stained with ochre, are found at sites in the southeastern Mediterranean and South Africa (e.g. Vanhaeren *et al.*, 2006; Bouzouggar *et al.*, 2007). In all documented modern human societies, bodily decoration of the kind these suggest is highly symbolic: of age, group membership, status, and so forth. It may be something of a leap to impute symbolic value to these ancient objects, whose larger context is lost to us; but it nonetheless seems likely in view of the larger context furnished by the Middle Stone Age of Africa. For the record soon provides us with more explicitly symbolic objects. Blombos Cave, on the southern African coast, has yielded two smoothed ochre plaques of slightly different ages, centering on about 77 kyr, that bear similar engraved geometric designs (Henshilwood *et al.*, 2002). The engraving of these two pieces at different times, in the same manner, strongly suggests that the motif involved was symbolic, retaining its meaning across the generations. This probability is reinforced by the finding of geometric engravings on ostrich eggshell fragments at the Diepkloof rock shelter, some 200 km away and some 60 kyr old (Texier *et al.*, 2010).

By the time of Diepkloof, such suggestions of symbolic thinking are supported by other evidence for modernity, such as the complex technologies first recognized at Pinnacle Point, and now at Blombos too (Mourre *et al.*, 2010). Other substantial technological advances were also being made in this general time period, most notably the development of damaging microlith-tipped projectile weapons that suggest a huge improvement in the efficiency of hunting techniques. While they perhaps furnish less direct evidence than symbolic objects do for the modern style of reasoning, these complex technologies are at the very least strongly suggestive of a highly sophisticated intelligence on the part of their practitioners. Additionally, it has been concluded (Marean, 2014) that the large-scale exploitation of marine mollusks documented at Pinnacle Point and at other sites of this period would have demanded a level of foresight and planning impossible in the absence of fully modern reasoning.

The most important point, though, is that the full corpus of indicators of modern behavior patterns is more significant than its individual components. Unlike such expressions as the mussel shell from Trinil and the "anthropomorph" from Berekhat Ram, these behavioral proxies from the MSA are not isolated points. Together with much other evidence, they suggest very strongly that something qualitatively new was going on within the MSA tradition in Africa. Previously, hominids had met environmental changes by adapting old technologies to new purposes, rather than by inventing new ones. Hence the typical stasis in stone tool kits. But, with the emergence of behaviorally modern *Homo sapiens*, a totally unprecedented entity was on the scene: one that clearly already possessed the restless appetite for change by which we are still being carried along today.

At around 70-60 kyr, molecular evidence suggests that waves of (unquestionably symbolic) *Homo sapiens* began leaving Africa, leading to the prompt extinction of the Neanderthals in Europe and of *Homo erectus* and *Homo floresiensis* in eastern Asia. By 40 kyr or thereabouts, spectacular cave art was already flourishing in Spain and France (Pike *et al.*, 2012); and representational rock art of comparable antiquity has been reported from Sulawesi (Aubert *et al.*, 2014), suggesting that both regional artistic traditions may have had earlier common roots in Africa. In Europe, where the evidence is best, cave painting was only the tip of a behavioral iceberg. It was accompanied by bountiful evidence for other art forms as well, such as sculpture and figurative engraving, and also for music in the form of bone flutes with a remarkable range of sound production. On the more directly practical front, notations for record-keeping were developed very early on (White, 1984). Population densities increased, exploitation of the environment intensified, and trade networks developed (White, 1984).

This radical reorganization of hominid life was unprecedented. In the two and a half million years since stone tools had first been made, technological change had been rare; and when it did occur it usually came in the form of minor refinement. Thus, while the first known African handaxes were certainly much more crudely shaped than the last ones that were made more than one and a half million years later, both were identifiably of the same category, implying similar intent on the part of their makers. The handaxe clearly exemplifies cognitive business as usual over a vast lapse of time. But, in the brief period between about 100 and 50 kyr ago, all the rules changed.

Becoming human

Hominid fossils are sparse at MSA sites, but there is no doubt that those early expressions of behavioral modernity in South Africa were the work of members of our own anatomically distinctive species *Homo sapiens*. As a result, a fairly firm scenario of modern human origins and geographical dispersion is beginning to emerge. *Homo sapiens* appeared as a distinctive anatomical entity in Africa at about 200 kyr ago. At first, members of this new species evidently behaved much as had their predecessors and hominid contemporaries. But by around 100 kyr ago, or shortly thereafter, they began to show new and unprecedented behavioral proclivities that were followed rapidly by dispersal out of Africa, and by swift colonization of the entire Old World. Almost certainly, the explosive expansion of the young species in the face of closely-related resident populations inside and outside Africa was made possible by the more sophisticated forward planning and more efficient environmental exploitation that the new symbolic style of reasoning permitted.

The entirely novel competitive entity represented by behaviorally-modern *Homo sapiens* appeared on the planet far too rapidly to be accounted for by the slow workings of natural selection at the individual level. Instead, we have to seek its origins in a short-term sequence of events. Since the neural underpinnings of symbolic thought must necessarily have been in place before the new cognitive proclivity could be expressed, we can most plausibly look to the developmental reorganization that accounted for the emergence of *Homo sapiens* at around 200 kyr ago. This was a radical event, for our species is highly apomorphic skeletally, and there is no evidence that its physical peculiarities were gradually acquired. What is more, there is no obvious reason why the change in gene regulation generating the new and distinctive structure should not have had ramifications that extended well beyond the hard-tissue features we can observe in the fossil record. On this view, when *Homo sapiens* acquired its anatomical identity it also gained a neural structure which permitted the complex associations necessitated by symbolic thought. But brain function of the old kind persisted until the new potential was behaviorally recruited, through the action of what was necessarily a cultural stimulus.

So what was that stimulus? Hands down, the best candidate is the invention of language. Several factors combine to make language particularly attractive as the releasing agent of symbolic thought. Most compellingly language is, as I have already argued, the ultimate symbolic activity, virtually synonymous with symbolic thought as we know it today. What is more, as outlined by Bolhuis *et al.* (2014, 2015) and Berwick & Chomsky (2016), its algorithmic basis is in all probability a rather simple one. This makes its invention very plausibly a more or less instantaneous event as suggested by Tattersall (2012, 2014), perhaps comparable to the spontaneous invention of a structured sign language observed when deaf Nicaraguan children were brought together in a school setting for the first time (Kegl *et al.*, 1999; Senghas *et al.*, 2005).

This property of suddenness distinguishes language from such rival putative drivers of symbolic thought as theory of mind, from which it also differs in being an externalized attribute that was poised to spread rapidly within an already biologically-enabled population. In this scenario, language and symbolic thought are inextricably entwined and were simultaneously acquired by *Homo sapiens* in a single short-term, exaptive and emergent feedback event. Exaptation is a routine evolutionary process whereby existing features are recruited to new uses (as birds recruited existing feathers for flight), and it also neatly explains how the modern vocal tract just happened to be in place at precisely the point when it was needed for the expression of language. Just like the neural structures that permit symbolic cognition and the generation of language, the airway proportions that allow the production of modern speech may simply be incidental byproducts of the retraction of the face below the braincase that is the most fundamental cranial apomorphy of *Homo sapiens*. This means that the long-running and vociferous argument over the condition of the larynx and various other structures of the upper vocal tract in fossil hominids is actually irrelevant to the precise point in human history at which language was acquired. The modern vocal tract was there first; and, of course, it had to be.

Our peculiar modern cognitive style is thus of recent and evolutionarily sudden origin. Resulting from the exaptive imposition of symbolic information processing upon a highly-evolved pre-existing intuitive system, it represents a radical departure from anything that preceded it. Although it was based on the fruits of a long evolutionary history – and nothing that occurred subsequently could ever have happened in the absence of everything that went before – our unique information-processing system was clearly not molded by long-term natural selection. And that, of course, means that we cannot blame our myriad behavioral deficiencies on a lingering biological adjustment to a vanished "environment of evolutionary adaptation." Instead, we are individually responsible for our own behaviors.

Acknowledgements

I wish to thank my co-organizers, Stefano Parmigiani and Telmo Pievani, for the opportunity to participate in the wonderful Erice conference at which these thoughts were presented. I also thank two reviewers for their constructive comments and Francesco Suman for his help throughout the production process.

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