CONSTRAINING THE TIME WHEN LANGUAGE EVOLVED

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The precise timing of the emergence of language in human prehistory cannot be resolved. But the available evidence is sufficient to constrain it to some degree. This is a review and synthesis of the available evidence, leading to the conclusion that the time when speech became important for our ancestors can be constrained to be not less than 500,000 years ago, thus excluding several popular theories involving a late transition to speech.

1. Introduction

That modern humans have language, and that our remote ancestors did not, are two incontrovertible facts. But there is no consensus on *when* the transition from non-language to language took place, nor any consensus on whether it was a sudden jump or a gradual process. In this paper, I will explore to what extent the timing of the transition to language can be constrained by fossil, archaeological, genetic, and other evidence. A fuller discussion of this and related issues can be found in Johansson (2005).

2. Upper limits

Very little can be said about upper limits on the age of language. Our closest relatives today do not have language in any reasonable sense, at least not in the wild. A reasonable inference from the lack of native ape language is that the last common ancestor of us and the other apes also lacked language. The alternative, that language evolved earlier and was subsequently lost in the chimpanzee lineage, appears implausible — why would something as useful as language be lost by a species heavily engaged in social communication?

The last common ancestor of humans and chimps almost certainly lived less than 10 million years ago (mya), and conceivably as recent as 4 mya. The current best estimate from molecular data is around 5 mya (Pääbo, 2003).

The oldest known fossils that with some confidence can be assigned to the human line are those in the genus *Ardipithecus*, from 4 - 6 mya, found in Ethiopia (Haile-Selassie, Suwa, & White, 2004). Other possible contenders for the earliest

proto-human fossil are *Sahelanthropus tchadensis*, a skull found recently in Chad (Brunet et al., 2002), from about 6-7 mya with a puzzling mixture of features making it difficult to classify, and *Orrorin tugenensis* (Senut et al., 2001) just below 6 million years old, found in Kenya.

The discoverers of *Ardipithecus*, *Sahelanthropus* and *Orrorin* all consider their own fossil to be a human ancestor, and the others to be side branches (Cela-Conde & Ayala, 2003). I find the case for *Ardipithecus* somewhat more compelling, but the jury remains out. All these fossils have sufficient similarities with both humans and other apes that they are likely to be quite close to the branching point in the family tree. This would give an estimate from fossils of the most likely age of the last common ancestor somewhere in the vicinity of 6 mya, consistent within the uncertainties with the molecular estimate.

But beyond this common ancestor there is no way to place any more stringent upper limit on the time of language emergence. It may appear unlikely that e.g. australopithecines possessed language 2-3 mya, but there is no hard evidence that excludes it. It has been argued both that a minimum brain size is needed for language, and that the presence of language implies a human-like material culture. Both of these arguments are somewhat plausible, but it is by no means established that they exclude language in Lucy.

Thus, the best firm upper limit that can be placed on the time of language emergence remains a bit beyond 5 million years ago.

3. Lower limits

All modern human populations have language, obviously. Given that language has at least some biological substrate (if not necessarily an innate grammar) this implies that the most recent common ancestor of all modern humans had language.

The molecular data strongly support a common origin for all extant humans somewhere around 100,000 – 200,000 years ago (Ayala & Escalante, 1996; Wood, 1997; Bergström et al., 1998; Cavalli-Sforza & Feldman, 2003). The so-called 'Mitochondrial Eve' (Cann, Stoneking, & Wilson, 1987; Saville, Kohli, & Anderson, 1998; Cavalli-Sforza, 1998), the putative common ancestress of all women, was at the forefront of this molecular wave, but she has since been joined by a corresponding 'Y-chromosome Adam' (Fu et al., 1996; Dorit, Akashi, & Gilbert, 1995; Pääbo, 1995), as well as by data from non-sex-linked genes (Fischman, 1996), and from X-chromosomes (Disotell, 1999). It follows that the origins of language cannot possibly be more recent than 100,000 years ago. This conclusion is consistent with archaeological evidence of the spread of *Homo sapiens* out of Africa and the peopling of various continents, notably Australia more than 50,000 years ago.

This 100,000-year lower limit already excludes theories that connect the origins of language with the apparent 'cultural revolution' in the archaeological record around 40,000 years ago, discussed in the next section.

For at least some aspects of language, stronger time limits are possible. Our habitual use of speech is reflected in certain aspects of our anatomy, that can be studied in fossils. Speech adaptations can potentially be found in our speech organs, hearing organs, brain, and in the neural connections between these organs.

• *Speech organs.* The shape of the human vocal tract, notably the lowered larynx, is a clear speech adaptation. The vocal tract itself is all soft tissue and does not fossilize, but its shape is connected with the shape of the surrounding bones, the skull base and the hyoid. Already *Homo erectus* had a near-modern skull base (Baba et al., 2003), but the significance of this is unclear (Fitch, 2000; Spoor, 2000). Hyoid bones are very rare as fossils, as they are not attached to the rest of the skeleton, but one Neanderthal hyoid has been found (Arensburg et al., 1989), very similar to the hyoid of modern *Homo sapiens*, leading to the conclusion that Neanderthals had a vocal tract similar to ours (Houghton, 1993; Boë, Maeda, & Heim, 1999).

• *Hearing organs.* Some fine-tuning appears to have taken place to optimize speech perception, notably our improved perception of sounds in the 2-4 kHz range. The sensitivity of ape ears has a minimum in this range, but human ears do not, mainly due to minor changes in the ear ossicles, the tiny bones that conduct sound from the eardrum to the inner ear. This difference is very likely an adaptation to speech perception, as key features of some speech sounds are in this region. The adaptation interpretation is strengthened by the discovery that a middle-ear structural gene has been the subject of strong natural selection in the human lineage (Olson & Varki, 2004). According to Martínez et al. (2004), these changes in the ossicles were present already in the 400,000-year-old fossils from Sima de los Huesos in Spain, well before the advent of modern *Homo sapiens*. These fossils are most likely Neanderthal ancestors, that Martínez et al. (2004) attribute to *Homo heidelbergensis*.

• *Brain.* Only the gross anatomy of the brain surface is visible as imprints on the inside of well-preserved fossil skulls. In principle, the emergence of e.g. Broca's area could be pinpointed this way. But other apes have brain structures with the same gross anatomy as both Broca and Wernicke (Gannon et al., 1998; Cantalupo & Hopkins, 2001), so the imprints of such areas in the skulls of proto-humans tell us nothing useful about language. Nor is there any clearcut increase in general lateralization — chimp brains are not symmetric.

• *Neural connections.* Where nerves pass through bone, a hole is left that can be seen in well-preserved fossils. Such nerve canals provide a rough estimate of the size of the nerve that passed through them. A thicker nerve means more neurons, and presumably improved sensitivity and control. The hypoglossal canal, leading to the tongue, is sometimes invoked in this context, but the fossil evidence is contradictory (Kay, Cartmill, & Balow, 1998; DeGusta et al., 1999). A better case can be made for the nerves to the thorax, presumably for breathing control. Both modern humans and Neanderthals have wide canals here, whereas *Homo er-*

gaster have the narrow canals typical of other apes (MacLarnon & Hewitt, 1999).

In conclusion, the fossil evidence indicates that at least some apparent speech adaptations were present in Neanderthals. None of these anatomical details is compelling on its own, but their consilience strengthens the case for Neanderthal speech in some form.

The presence of speech in Neanderthals sets a lower limit for the age of speech at the time of the last common ancestor of us and the Neanderthals (unless one postulates, implausibly, the independent evolution of the same set of adaptations in both lineages). It has long been a controversial issue whether the Neanderthals actually were a separate lineage, or just a subspecies of *Homo sapiens*, but genetic evidence from Neanderthal fossils clearly demonstrates their separateness, and indicates that the last common ancestor lived at least half a million years ago (e.g. Krings et al., 1999; Höss, 2000; Beerli & Edwards, 2002; Knight, 2003; Caramelli et. al., 2003)[a]. The fossil evidence points in the same direction, with the earliest modern humans in Europe more resembling Africans than Neanderthals (Tyrrell & Chamberlain, 1998).

There is no consensus on the taxonomy of the transitional fossils from around the time of our common ancestor with the Neanderthals. The names *Homo heidelbergensis, rhodesiensis, antecessor, helmei* and others are all in current use. It is, however, quite well established that all of these have their roots in *Homo erectus (sensu lato)*, so I will use the name *erectus* for our last common ancestor.

4. The revolution that wasn't

The archeological record has frequently been invoked as support for the late, sudden appearance of language, due to the perception of a technological and creative revolution around 40,000 years ago (e.g. Binford, 1989; Li & Hombert, 2002).

Language use in itself is not archeologically visible, but other forms of sign use may be, and may be used as indicators that some level of semiotic abilities has been reached. Invoking ancient art, including pigments and personal ornaments, as indicators that the artists were capable of symbolic thought, or even as an indicator that language had evolved, is fairly common (Mellars, 1998).

The supposedly sudden appearance of advanced art and advanced tools in the caves of Europe about 40,000 years ago is taken as evidence of a cognitive leap. However, the appearance of a sudden dramatic 'cultural revolution' around 40,000 years ago, has turned out to be largely an illusion caused by the predominance of European sites in the documented archeological record, and possibly some Eurocentrism among archeologists (Henshilwood & Marean, 2003). *Homo sapiens*

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[a]Some studies of genetic statistics in modern humans support some degree of admixture, e.g. Eswaran, Harpending, and Rogers (2005), but this must carry less weight than the direct evidence from fossil Neanderthal mtDNA, which is consistently distinct from either recent or fossil *Homo sapiens* mtDNA.

did indeed invade Europe rather suddenly about 40,000 years ago, bringing along an advanced toolkit — but that toolkit had been developed gradually in Africa over the course of more than 200,000 years (McBrearty & Brooks, 2000; Van Peer et al., 2003). Recent discoveries of works of abstract art (Henshilwood et al., 2002), pigment use (Barham, 2002), and personal ornaments (Henshilwood et al., 2004), all substantially older than 40,000 years, add further support to the long timescale of McBrearty and Brooks (2000). The debate over the supposed revolution is reviewed by Bar-Yosef (2002) or Henshilwood and Marean (2003).

Additional evidence has been uncovered recently that appears to show that simple art may actually have predated the appearance of anatomically modern *Homo sapiens* (Bahn & Vertut, 1997; Keys, 2000; Bednarik, 2003), in the context of *Homo heidelbergensis* or possibly even *Homo erectus*. Objects that can reasonably be interpreted as art have been found associated also with Neanderthals (Appenzeller, 1998; d'Errico et al., 2003; Wynn & Coolidge, 2004). While these finds are much simpler than the figurative art of later *Homo sapiens* (e.g. Bahn & Vertut, 1997; Conard, 2003), they nevertheless push back the origin of the biological capacities needed for simple art at least to the common ancestor of Neanderthals and us, some 500,000 years ago. And given that the symbolic capacities needed for art are also needed for language, and are interpreted by some as indicative of the presence of language, this adds support to the time limit inferred from anatomy in the previous section.

5. Conclusions

Fossil evidence indicates that speech optimization of our vocal apparatus got started well before the emergence of *Homo sapiens*, almost certainly more than half a million years ago, probably in *Homo erectus*. As the speech optimization, with its accompanying costs, would not occur without strong selective pressure for complex vocalizations, presumably verbal communication, this implies that *Homo erectus* already possessed non-trivial language abilities.

There is no real evidence indicating just how complex language *erectus* had. It must have been complex enough to require fine-grained vocal distinctions, but this need not imply anything like modern grammar. They may have been at a holophrastic stage, or they may have had nearly full human language — it is difficult to imagine any way to tell. On one hand, *erectus* is the first hominid with a brain size approaching the modern human range — there are modern humans alive today with *erectus*-sized brains and excellent language skills — and they were also the first to spread out to many different habitats on different continents. But on the other hand their comparatively simple, static culture argues against their having modern human cognitive skills. In particular, it is quite clear that they lacked the cumulative cultural evolution that is so characteristic of modern humans. Given that they are different from modern humans in such fundamental ways, their having full modern human language appears unlikely.

Language need not have started in a spoken modality; sign language may have been the original language (e.g. Corballis, 2002), likely building on mimesis (Donald, 1997; Zlatev, Persson, & Gärdenfors, 2005). This means language may be older than speech — but hardly younger. A lower age limit on speech remains a firm lower limit on the age of language at the *erectus* level, if not necessarily on full modern grammar.

Modern humans, after parting company with the Neanderthals perhaps half a million years ago, would have acquired the remaining features of modern language in parallel with acquiring modern human anatomy. Both aspects were finished before modern humans started spreading over the world, at least 100,000 years ago. The last common ancestor of all humans today, probably living in Africa not so long before this exodus, is the likely speaker of Proto-World, the common ancestor of all the modern language families, and the earliest language which we may have any remote hope of ever reconstructing. But there is no reason to believe that this Proto-World was the *first* language spoken — as discussed above, our ancestors may have had language for a million years already. The details of those earlier proto-languages are likely to remain opaque for the foreseeable future.

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