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# A “Sudden Appearance” model for the Evolution of Human Cognition and Language

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## Abstract

The debate over the evolution of an innate language capacity seems to divide into two principle schools of thought. Jackendoff (1999a, 1999b) has argued that language processing is based on three autonomous generative components, phonological, syntactic, and semantic/conceptual and he is committed to the view that the language faculty evolved incrementally through natural selection. Pinker (1994, 333) also sees “no reason to doubt that the principle explanation is the same as for any other complex instinct or organ, Darwin’s theory of natural selection”, when theorizing about language evolution. An alternative approach has been taken recently by Hauser, Chomsky and Fitch (2002). They argue that the property that makes human language unique (recursion), may be a recent emergence in hominid evolution. It follows from this line of thought that most of the anatomical characteristics that support language (e.g. vocal tract and controlled breathing) may be merely variations of previously evolved biological structures, and not of a different kind. Leaving aside the argument of whether these structures evolved gradually, they did not evolve nor were they “tuned” to serve the faculty of language. Jackendoff (1999a) accuses those who do not accept that language arose gradually through natural selection as having been “forced to devalue evolutionary argumentation”. Jackendoff’s concern seems to stem from the view that there is only one way that evolution can proceed, through gradual change honed by natural selection. My concern is for the neglect of the vast amount of evidence supporting the theory that modern humans did not emerge in a gradual, step-wise fashion. Here I argue that hominins evolved through major evolutionary leaps, which may have numbered only two or three significant mutation “events”. Neoteny (the retention of infant or juvenile growth rates) has been the major force in the evolution of our primate ancestors and this process can explain the sudden emergence of many of the traits that define what it means to be human, including the sudden emergence of human cognition and language.

## How do we define what is human?

When we find a primate fossil of any antiquity, we generally look for certain traits that are deemed to separate the hominin<sup>1</sup> clade from the Great Apes. The key defining trait is bipedalism, which can be deduced from the shape of the pelvis, spine, knee and foot bones. Another trait is the morphology of the teeth, especially the reduction in size of the canines, which lose their ‘dagger-like’ appearance. Some variations in skull, jaw and face

<sup>1</sup> *Hominins* refer to humans and all ancestors back to the human/ape split.

shape can also define a move away from an ape-like cranial morphology.

Naturally, we cannot deduce the behaviour directly from any fossilized hominin bones although the context in which they are found can sometimes prompt some intuitions about their life-style. Unless we uncover some evidence for a written language or notation among these remains, we will never be able to say for certain whether any of these hominins could speak or use a signed language. However, by showing that both the anatomy and the behavioural traits of modern humans did not evolve gradually over time, I believe that doubt must be cast on accounts that posit a gradual evolution of modern human cognition and language.

## Evolution - Gradual vs Saltational

Evolution by natural selection in the Darwinian tradition is the most commonly attested theory for the evolution of modern humans. This theory assumes that human evolution, including of course, the evolution of the brain, has progressed incrementally as a trend toward complexity. Regardless of the “unit of selection”, be it the phenotype or an individual gene, the neo-Darwinian model emphasizes gradualism. Most current human traits are assumed to be the result of an adaptive advantage in our past, and they have survived to serve the reproductive success of an individual, or the entire species. Numerous neo-Darwinian evolutionary accounts of the twentieth century have proposed that traits like bipedalism, a large brain, language, tool use and other characteristics of hominins, must have evolved together while maintaining some sort of feedback mechanism that has “fine tuned” or “gradually” adapted each characteristic feature to a changing environment.

Thus Pinker (1997) has argued that since the emergence of bipedalism a few million years ago, and with the hands freed, subsequent species ratchet upward, click by click, in the features that distinguish us, like the size of the brain and the sophistication of tools. Pinker’s interpretation of the fossil record also sees a gradual reduction in the brow ridges as well as the in the teeth and jaw because “tools and technology have taken over from teeth” (Pinker, 1997, 200).

The problematic nature of Pinker’s account of how the evolution of humans has proceeded is suggested by the paleontological and archeological evidence. The first stone tools appear around 4 million years *after* bipedal-

ism emerged, hardly a “click by click” scenario. Moreover, the brow ridges, which come in various configurations and sizes, did not gradually shrink and disappear. Neanderthals, who survived in Europe until around 30,000 years ago, and the latest hominin found in Indonesia, who existed 18,000 years ago, had large brow ridges, just like the first australopithecines. Also, brain size does not gradually increase, but shows only two or three major transitions that appear suddenly in the fossil record.

Following the “gradualist” school, Jackendoff claims to be able to decompose modern language into partially ordered steps that have evolved incrementally to be finally integrated into the larger combinatorial system. These modules are assumed to be innate, localized and part of our genetic inheritance. He “assume[s] without justification that any increase in explicit expressive power of the communication system is adaptive, whether for cooperation in hunting, gathering, defense, or for social communication such as gossip” (Jackendoff, 1999a).

Jackendoff’s intuition, that an increase in the expressive power that language provides, would be an advantage, is not disputed. Nor is his claim that the language faculty exhibits a degree of modularity such as a lexicon, a computational component, semantics, morphology, the phonological component, and phonetics (Jenkins, 2000). But, as Bickerton points out, “there is simply not one scintilla of evidence: simply a blind faith that, if evolution is gradual, and we are where we are, we must have got here, far as it may seem, in a series of incremental steps” (Bickerton, 2002, 104).

The self-proclaimed “unblushing adaptationist”, Daniel Dennett, cannot understand that anyone, particularly Chomsky, could believe that something like the “language organ” could be innate, but that is was not a product of natural selection (Dennett, 1995). Chomsky simply argues that we can concoct as many adaptationist stories as we like, but “it remains to explain how the biological endowment developed; the problem is simply displaced, not solved” (Chomsky, 1988, 166). It seems to me that the best way to grapple with the issue is to follow Deacon’s approach, where he argues that “knowing how something originated often is the best clue to how it works” (Deacon, 1997, 23).

Accordingly, we should tackle the question of when modern human cognition and language arose by looking at the archaeological and paleontological record. I argue that the saltationist approach to the evolution of the human ancestral line matches closely with the paleontological evidence, whereas the neo-Darwinian approach, based on Mendelian genetics, is quite contradictory to that evidence. Schwartz (1999) points out that Mendelian principles of inheritance show how natural selection can move a population toward a certain trait, but it cannot produce anything new. If for example height was being selected, then the average individual of the following generation would be taller, but this cannot go on indefinitely. The next generation will not exceed the maximum height of the preceding generation.

## Evolution through Developmental Change

Rather than evolving in gradual, incremental steps from an ancestral primate, the hominin clade has arisen due to the heterochronic<sup>2</sup> variation in form during the early stages of development producing the novelty that we see in the first hominins as well as modern humans.

The affinity of the juvenile form of both chimpanzees and ancestral hominins, as well as the likeness of some juvenile hominins and modern humans, shows that most of the skeletal traits of the hominin line arose primarily due to changes in developmental timing in the early stages of ontogeny. Neoteny<sup>3</sup> has been a major factor in the evolution of ancestral hominins. It is interesting to note that the first discoveries and classification of *Australopithecus africanus* by Dart in the first half of the twentieth century, were rejected by many claiming that these remains were those of a juvenile gorilla (Wong, 2003).

Most of the traits that separate us from the apes, namely bipedalism (with the associated modifications of the spine, pelvis, femur and knee), skull and face shape, and dentition, can be explained by the process of neoteny. I can find little or no evidence to suppose that up until the sudden appearance of modern humans around 120,000 years ago, all of our hominin ancestors, including *Homo erectus*, Neanderthals and the predecessors of humans, were little more than “grown up” juvenile chimpanzees with little more cognitive ability of the same. The “final” mutation, which seems to have occurred in an ancestral species living in Africa, profoundly modified the neural architecture of the human brain, which gave rise to the sudden appearance of our modern symbolic thought and language capacity.

### Hominins and Juvenile Chimpanzees

Chimpanzees are born with the skull positioned on the top of the spinal column, just like human infants. The newborn chimpanzee is bipedal with a human-like pelvis shape. The skull of the chimpanzee is also similar to that of a human with a flat face, without brow ridges, without cranial crests, same position of orbits, thinness of bone and a high domed forehead. The infant chimpanzee also has a small human-like jaw and palate. All of these human-like features change dramatically during the juvenile growth spurt of the chimpanzee. Penin et al. (2002) have recently confirmed the hypothesis for the neotenic emergence of the human skull shape. Their results show that the adult skull in humans reaches a size-related *shape* that is equivalent to that of a juvenile chimpanzee but nevertheless grows to a size similar to that of an adult chimpanzee.

<sup>2</sup>Heterochrony is a process whereby developmental (Hox) genes control the timing and onset/offset of the expression of other tissue building genes.

<sup>3</sup>The retention of the juvenile characteristics of one’s ancestor.

## The first “Sudden Appearance”

The earliest fossil hominins dating to around 6-7 million years ago are found in Africa where they existed up until 1.2 million years ago (Mirazón Lahr and Foley, 2004). The defining features of these australopithecines were bipedalism, small stature (1-1.5 metres tall) and reduced sized canines. The australopithecines show a mosaic of ape-like and human-like features including tooth size and shape, face shape, brow ridges, brain case size, femur shape, pelvic size and shape and various configurations of foot bones that may mean full bipedalism or some retention of the ability to retain an arboreal, climbing lifestyle.

The most plausible account for the emergence of the first hominin is for a simple neotenus mutation that produced a chimpanzee/s that did not go through the normal juvenile growth spurt thereby retaining its bipedalism, skull shape and reduced canines. This creature interbred with the original chimpanzee group to produce *all* of the variation that we now find in the fossil record over a five million year time span. It is important to note that these hominins retained chimpanzee-sized brains throughout their approximately 5 million year history (Mirazón Lahr and Foley, 2004). Importantly, there are no stone tools associated with australopithecines<sup>4</sup>

The implications of this stasis for the evolution of human-like cognition and language are quite profound. It is generally agreed that a fundamental requirement for the use of language is the capacity for symbolic thought. Sterelny (2003) stresses the fact that we rely on the symbolic meaning in each of our utterances to be understood by our audience. We need a rich theory of mind for language to operate successfully. Despite many years of experimentation with Great Apes, there is little evidence that they have rich ways of representing the minds of others. We therefore have no reason to suppose that the australopithecines had made any major cognitive advance over the Great Apes and were probably not capable of using language.

So, for up to 5 million years, the hominin clade appears to have been simply bipedal apes. This conclusion is difficult to reconcile with the notion that language has evolved gradually and incrementally, as Jackendoff and Pinker claim. The more compelling evidence from the paleontological and archaeological record reveals an astonishing stasis for this great expanse of time.

### *Homo erectus*

Around 2 million years ago, after around 5 million years of stasis, *H. erectus*, a generally much larger hominin than the australopithecines and the first toolmaker<sup>5</sup>, first appears in Africa. Shortly after their emergence they migrated to most other accessible continents. The stone

<sup>4</sup>The first crude stone tools, known as the Oldowan tradition, appear in the archaeological record 2.5 million years ago and are attributed to *Homo habilis*, although there are no stone tools directly associated with the fossil remains of this hominin.

<sup>5</sup>The first stone tool makers *H. habilis*, were hardly bigger or more advanced in their body skeletons than the australopithecines.

tools found with this species were effectively identical to the first stone tools that appeared in the record 500,000 years earlier (Tattersall, 1997). This suggests that although this early *H. erectus* population was larger in physical size and cranial capacity than *H. habilis*, it had not developed any increase in cognitive ability.

Noble and Davidson (1997) have convincingly argued that the the first stone tool technology, the Oldowan industry, shows little sign of any advance over the tool making abilities demonstrated by modern apes. The bonobo ‘Kanzi’, given some incentive like a food reward, can easily make a cutting flake in order to cut the string from a box containing a treat.

After extensive analysis of the fossil record of most of the *H. erectus* remains covering Africa, China, Europe and South East Asia, Rightmire (1990) has concluded that this species had maintained a conservative morphology throughout the Pleistocene. *H. erectus* features vary, but these variations were not on a scale greater than those found within contemporary modern human populations. These variations can be found within geographically widespread groups and cannot be placed within a specific time-line of size or complexity. For example, his work in Olduvai (Africa) has revealed a 1.25 million year old cranium with a capacity of 1067 ml, whereas a 730,000 year old fossil exhibits a brain size of only 700-800 ml. For Far East fossils, the story is the same. Cranial capacity varies between 800 ml and 1250ml.

Despite the obvious increase in cranial capacity around 2 million years ago, Walker and Shipman (1996) argue that any difference in brain size from *H. habilis* to *H. erectus* was simply due to an increase in body size. *H. erectus* had a body size slightly larger than most modern humans, but nevertheless had only a brain the size of a one year old human.

The remains of the latest hominins, which survived right up until 18,000 years ago, have been recently found on the island of Flores, Indonesia. Named *Homo floresiensis* (Brown et al., 2004), this one metre tall species has more in common with australopithecines and early African *H. erectus* than later fossils of Javan *H. erectus*. It had a chimpanzee sized brain, a low brain-case with a prominent brow ridge, and no chin. A similar find from Dmanisi in Georgia (Gabunia et al., 2001) that dates to 1.8 million years ago, link these early hominins with the small stature and brain size of *H. habilis* and *Australopithecus*. These fossils are associated with the primitive tool technology that is first found in Africa dating to 2.5 million years ago. Importantly, these crude tools are remarkably similar to those associated with the small hominins found recently on Flores. Once again we find a stasis in hominin traits and technology that lasted for well over 2.5 million years.

Although the postcranial anatomy of *H. erectus* is similar to that of *H. sapiens*, there are some important differences. *H. erectus* had 6 lumbar vertebrae, a configuration that is found in the first australopithecines and the vertebral body surface is also more ape-like than that of a human. The canal that carries the spinal cord is much narrower, in fact only half the size of that of a

human. Humans have dramatically increased the gray matter in the spinal cord, which takes up most of the room in the newly enlarged spinal canal. This newly evolved, more complex configuration, has given modern humans a much greater control over posture, coordinated bipedalism, fine motor control with the hands, and most importantly, control of breathing (MacLarnon and Hewitt, 2004).

This enhancement in modern humans has important implications for the evolution of language. We need the fine control over our abdominal muscles to control breathing as we speak. The fact that *H. erectus* had the spinal column more like that of an ape than a human, casts doubt on many of the abilities that are unquestionably attributed to this species, namely coordinated running and walking, fine motor control over the hands for making stone tools, and breathing control necessary for spoken language (Walker and Shipman, 1996). Pinker and Jackendoff (2005) acknowledge that modern humans have this enlarged region of the spinal cord, in comparison with pre-*sapiens*, yet they still maintain that this anatomic feature was an adaptation for speech. This claim is at odds with the fossil record, which does not show this trait evolving ‘piecemeal’ or gradually to subserve language, but emerges very late in our evolutionary history.

Pinker and Jackendoff appear to accept evidence that the larynx was recently adapted for speech. MacLarnon and Hewitt (2004) note that shape of the basicranium of *H. erectus* indicates that the larynx and hyoid were both situated in the same position as apes. However Pinker and Jackendoff overlook this fact when claiming that the descended larynx is part of a suite of vocal-tract modifications that were evolutionarily shaped to “subserve” language. There is no gradual evolution of the morphology of the spinal column or the vocal tract that is being “fine-tuned” to serve language. These modifications appear to have arisen only with the sudden appearance of anatomically modern humans.

We should now test Pinker’s (1997) assertion that an increase in the sophistication of stone tools is one of the keys to understanding the gradual increase in human cognitive complexity. Around 1.4 million years ago, a relatively standardized and symmetrical stone tool was being made in Africa (Tattersall, 1997). This tear-drop shaped acheulian hand-axe, known for its distinctive shape, and associated with *H. erectus*, remained unchanged for one million years. It is found wherever *H. erectus* roamed, which covered a distance of 10,000 miles from Africa to Japan. Bickerton (2002, 105) asks the question, “is it possible to think of any *sapiens* innovation that has traveled for the best part of 10 thousand miles without undergoing the slightest change?”. He adds that “the mismatch between the fossil and archaeological records forms an acute embarrassment for those who believe that human cognitive capacities, including language, developed gradually” (Bickerton, 2002, 106). Furthermore, Noble and Davidson (1997) have put forward convincing evidence that these so-called sophisticated hand-axes were actually the discarded remains of a

production process that produced the prized single flakes that had been struck from an original core. The resultant symmetry is merely the end of a process, which was determined by the nature and size of the original material, and not the product a pre-determined shape of the mind of the knapper.

Moreover recent experiments have shown that elaborate stone tools can be produced without the use of language at all (Tattersall, 2001). Groups of undergraduates were divided into two groups, one half taught to make a stone tool by verbal explanation, the other by silent example. The two groups showed no difference in efficiency or speed of acquisition of the toolmaking skills.

## Our Recent Ancestor?

Recent excavations of a 800,000 year old cave site in Atapuerca, Spain, have uncovered the skull of a juvenile hominin, which has the face of a totally modern human (Arsuaga et al., 1999). Arsuaga, argues that this human-like face may explain how modern humans emerged due to a mutation that caused the retention of juvenile morphology (neoteny) of this ancient species, which he has named *Homo antecessor*. In discussion with Kunzig (1997), he argues that our modern face has not evolved by natural selection, reducing the large prognathous face of our adult ancestors, but by a neotenuous mutation whereby a juvenile ancestor did not go through a particular stage of development, which would produce the ‘normal’ adult morphology of that species.

However, as Kunzig points out, this 800,000 fossil with the face of a modern human, raises some interesting questions relating to the nature of human evolution. The tools found alongside *H. antecessor* were archaic for their time, resembling the 2.5-2.6 Myr old Oldowan tradition from Africa. It appears that this population had retained the same tool technology for nearly two million years!

In addition, evidence of cannibalism of the young members of this hominin species seems at odds with any notion of an increase in complexity of social cooperation that is often put forward as a driving force of human evolution. Although recent human groups have been known to slaughter one another for ritual purposes, the victims of *H. antecessor* had been dismembered and butchered like all other animals. The remains of infants were found along side those of other animal bones that were stripped of anything edible in the same way. Bermudez de Castro et al. (1999) suggest that the site indicates gastronomic cannibalism rather than a survival strategy, and they exclude any possibility of ritual intentionality. They question whether gastronomic cannibalism could ever be an evolutionarily successful strategy, especially when the victims were infants and young individuals. We can witness today the same systematic killing of infants and juveniles, and cannibalism of infants of neighboring communities, among the wild chimpanzees at Gombe National Park (Wilson et al., 2004).

Pinker (1997) has argued the case for primate social organisation, which he believes promotes a need for better information exchange and that this *need* provided the pre-adaptation for hominins to move into a new “cogni-

tive niche". This may be so, but it appears, at least to my mind, that these hominins, even at this late stage in evolution, simply did not have the cognitive architecture that allowed them to move into this niche.

*H. antecessor* is thought to be the ancestor of both modern humans<sup>6</sup> and the Neanderthals, who are found mainly in Europe from 200,000 years ago. There have been many fossil finds of Neanderthals in Europe, but it is interesting to note that old age for this species was only 40-50 years (Stringer and Gamble, 1993), which is the same maximum life expectancy as extant chimpanzees. Stringer and Gamble note that of the entire sample of Neanderthals, fewer than 10 percent were aged over 35 at death, with most of the aged fossils showing the same illnesses (e.g. arthritis) that we find in aged modern humans.

Although *H. erectus* did not have the capacity for fine control over the production of speech sounds, it appears that *H. heidelbergensis* may have evolved a similar configuration as that of modern humans. The capacity for speech seems to be a recent phenomenon in hominin evolution and may have been made possible due to the greater control over breathing (MacLarnon and Hewitt, 2004). Recent pre-modern humans seem to have developed larger thoracic vertebrae than *H. erectus*, which may have enabled this greater control.

The problem nevertheless remains whether pre-modern hominins, like *H. heidelbergensis* and the Neanderthals, had the fine *neural* control over their actions. MacLarnon and Hewitt have analyzed the differences between the gray and white matter, which makes up the soft tissue in the spinal cord. The gray matter, containing nerve cell bodies, is more abundant in humans than other primates. This enlargement is directly related to the innervation of motor functions controlling the thoracic and abdominal muscles implicated in the fine control over breathing that is important for speech (MacLarnon and Hewitt, 2004). We cannot say whether pre-modern hominins had evolved a greater mass of nerve cell bodies to support fine breathing control, however, other evidence from the configuration of the basicranium in these hominins indicates that the larynx was still high in the throat, precluding the ability for articulate speech (MacLarnon and Hewitt, 2004).

## The Appearance of Modern Humans

The first appearance of anatomically modern humans emerged in Africa by around 120,000 years ago (Stringer, 2003). The fossil record in Africa closely matches the latest genetic evidence for this recent emergence. Pearson (2004) has pointed out that MtDNA and the X and Y chromosomes in all modern humans show a very low diversity, especially compared to Apes. It appears that an anatomically modern population emerged in Africa and subsequently replaced all other hominin populations living there at that time. Pearson suggests that these first modern humans grew in population over a period

<sup>6</sup>*H. heidelbergensis* may have been an intermediary population that emerged between 600,000 and 400,000 years ago in Africa.

of 60,000 years, but remained in Africa, explaining the greater genetic diversity that is found there today. After 60,000 years, these modern peoples then dispersed to the Near East, South East Asia and Australia, and then on to Europe and the Far East.

Pearson's genetic findings are matched by clear evidence from the archaeological record, that most of what we recognize as fully modern human intentional and symbolic behavior, arose suddenly in southern Africa, between 90,000 to 100,000 years ago (Mellars, 2005). New forms of skin working technology appear along with highly specialized geometric blades, used as insets in multi-component hafted tools, together with intricately shaped barbed bone points. High quality raw materials had been deliberately transported from a distance of at least 20 km. Many sites have an abundance of red ochre showing signs of scraped surfaces indicating their use as coloring pigments. Other large pieces of ochre have been deliberately incised with repetitive geometrical patterns from which we can infer some sort of symbolic or ceremonial activity (Mellars, 2005). Large amounts of red ochre are also associated with ceremonial burial. We find an abundance of carefully perforated shells, which again had been imported from long distances. Their use as personal ornaments is confirmed by unambiguous indications of elaborate ceremonial burials associated with a range of perforated seashells (Mellars, 2005). We cannot say whether or not these first humans had language, but we can be sure that they were engaging in symbolic behaviour, making it highly likely that some form of language was at least possible.

It appears that the first modern human population remained very low, judging by the types of faunal assemblage found in caves that date to 90,000 years ago. Klein (2000) has pointed out that wherever we find large ungulate and tortoise bones together with the larger specimens of marine shells, we can infer low population density that is not over-exploiting the available resources. Nevertheless, we can surmise from the fossil and archaeological record, that at least one group of *H. sapiens* move out of Africa, around 40,000-50,000 years ago, and completely replaced all other hominins living at that time Tattersall (2001).

## Conclusion

I have proposed that the archaeological and paleontological record does not support theories that argue for gradual change for the evolution of the hominin clade. Rather, we see the "Sudden Appearance" of the first hominins around 6-7 million years ago due to a neotenus mutation of an ancestral ape, followed by an astonishing stasis in bodily form and brain size for at least 4 million years when the first stone tools appear. We then find the sudden appearance of *H. erectus* who again shows little variability in either physiology or tool technology for 2.5 million years. It has been shown that any variability in all of these ancestral hominins is no more than we find today among modern humans. The final sudden appearance produced anatomically modern humans (*H. sapiens*), which emerged in Africa around 120,000 years ago

with the cognitive architecture to support an extraordinary array of symbolic behaviour not seen before in any ancestral species. I therefore contend that arguments belonging to Jackendoff and Pinker, that claim that our mind and language faculty are highly modularised due to the gradual accretion of functionally specific components, which have evolved gradually over evolutionary time, are not tenable.

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