



Ralph F. Stearley

## Article

# Assessing Evidences for the Evolution of a Human Cognitive Platform for "Soulsh Behaviors"

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*During the past one hundred fifty years, a great number of fossil hominid specimens have been unearthed, providing an outline of hominid history extending back five million years. Associated with these hominid fossils are artifacts. Christians and others who have attempted to assess the humanity of these long-dead individuals have focused on evidences of cognition such as cave art, evidences of care given to injured or ill individuals, or burial. However, many more types of evidences as to cognitive abilities in these creatures are available.*

*Warren Brown has proposed that a cluster of interlinked cognitive capacities were elaborated over the past few million years of hominid history during an "evolutionary trajectory" which, in turn, undergird human "soulsh behaviors."<sup>1</sup> These include language, a theory of mind, episodic memory, top-down agency, future orientation, and emotional modulation. This article is an attempt to put traction on Brown's proposal, through detailed examination of the paleoanthropological record. The ability to teach, and thus symbolically and rapidly transmit culture, is suggested as an additional capacity which is part of this cognitive platform. Primary data (anatomy, artifacts) and reliable inferences (based on comparative studies) support a notion of a stage-wise erection of a cognitive platform for soulsh behaviors. A few significant, less-understood gaps remain in the cognitive trajectory.*

**T**hrough the course of the past five hundred years, voyages of exploration, the development of a science of comparative biology, and revelations provided by the unearthing of fossil hominids have combined to establish that humans occupy a position

in a genetic continuum of life on Earth. In addition, natural and human experiments on brain function have demonstrated that the human mind is, in turn, founded on this biological history. Many theologians, scientists, and lay Christians have pondered these discoveries during this interval. How should this historical continuity be juxtaposed to the Christian concept of the unique creation and calling of humanity? As cynically phrased by the paleontologist Stephen J. Gould, are humans "... only an afterthought, a kind of cosmic accident, just one bauble on the Christmas tree of evolution"??

**Ralph Stearley** is a paleontologist with broad interests in the history of life. He received his BA in biological anthropology from the University of Missouri and MS and PhD in geosciences with emphases on paleontology from the University of Utah and the University of Michigan respectively. He is professor of geology at Calvin College, where he has taught since 1992. His published research has included work on marine invertebrate ecology and paleoecology, fluvial taphonomy, the systematics and evolution of salmonid fishes, and Pleistocene mammalian biogeography. He was privileged to be able to co-author, with former Calvin colleague Davis Young, *The Bible, Rocks and Time*, published by InterVarsity Press in 2008.

In the fifteenth and sixteenth centuries, contact with hitherto unknown human groups posed some vexing theological questions for many Christian theologians, historians, and natural philosophers.<sup>3</sup> While most orthodox theologians agreed that these “new” human groups were descended from Adam, many realized that the (post-Noachic Flood) Table of Nations in Genesis 11 did not include the ancestors of the residents of the New World. Thomas Burnet (1681), for example, responded by suggesting “the Almighty, we may reasonably suppose, made provision for a saving remnant in every continent.”<sup>4</sup> However, some Christians questioned whether these new peoples were indeed descended from Adam. Could there exist New World and other humans, patently bearing God’s image, who yet did not descend from Adam and Eve? Could such beings as “Preadamites” have existed in the distant past?<sup>5</sup>

During the seventeenth and eighteenth centuries, well-executed anatomical studies of apes by Nicolas Tulp, Edward Tyson, and Petrus Camper confirmed their strong similarities to human beings.<sup>6</sup> Carolus Linnaeus, pious Lutheran and astute biological organizer, in his first edition of the *Systema Naturae* (1735), included humans with baboons, other monkeys, and apes under Class Quadrupedia and Order Anthropomorpha.<sup>7</sup> In his tenth edition, he erected the Order Primates for monkeys, apes, humans, and bats; in his notes to the twelfth edition, he commented, “It is remarkable that the stupidest ape differs so little from the wisest man, that the surveyor of nature has yet to be found who can draw the line between them.”<sup>8</sup> Many of Linnaeus’s contemporary natural historians, including the Comte du Buffon, objected to Linnaeus’s placement. Operating under a Cartesian concept of the mind as a separate substance added to the body, they suggested humans were a distinct biological category.

In the third quarter of the nineteenth century, T. H. Huxley, Ernest Haeckel, and Charles Darwin reframed the comparative anatomy of apes and humans in a phylogenetic context.<sup>9</sup> Although finds of hominid fossils were then very rare, these authors made predictions regarding the locations and types of discoveries which would eventually be made. The “preadamite” controversy had thus been amplified to include potential human biological ancestry from an anthropoid primate stock. Since that time, a plethora of fossil hominid remains and artifacts

have been unearthed and analyzed. The fossils and artifacts testify to a protracted history to the hominid lineage.

Furthermore, during the past two centuries, evidences have accumulated which link aspects of human responsible decision-making and socialization to specific brain activities. These evidences include case studies of patients with physical damage to the brain; neuroimaging studies of subjects undergoing tasks; and experiments which play one aspect of cognition against another, often by combining two or more demanding tasks simultaneously.<sup>10</sup> Many Christian neuroscientists, cognitive psychologists, and philosophers, deeply impressed by the evidences for the psychosomatic unity of the individual, now advocate a reversal of the Cartesian stance: the mind is not a separate substance from the body.<sup>11</sup> Many biblical texts describing human nature also treat humans as psychosomatic unities. Such lines of evidence provide a rationale for viewing the human soul as a set of emergent qualities or capabilities, and not a separate entity from the body; this viewpoint is sometimes referred to as “non-reductive physicalism.”<sup>12</sup> In this article, I do not attempt to take a position on the human soul as emergent, although the observations presented here are relevant to the discussion.

Warren S. Brown feels compelled to adopt a view of the human soul as emergent. In his account, distinctly human capacities to *relate*—to oneself, to other humans, and to God—are the (evolved) earmarks of human uniqueness. Brown identifies six specific cognitive requisites for what he terms “soulish” existence. These are (1) language; (2) meta-cognitive skills, including a theory of mind; (3) episodic memory; (4) conscious top-down agency; (5) future orientation; and (6) emotional modulation.<sup>13</sup> Brown’s proposal actually provides reasonable and approachable targets for detection in ancient hominids, regardless of one’s viewpoint on the soul. These six cognitive capacities are phenomena needing explanation in any evolutionary scenario for the emergence of truly *human* existence. I suggest that the capacity to teach should be added to this list.

This article attempts to clarify some issues surrounding the nature of ancient hominids, specifically by addressing evidences or clues for cognition in these forms. Brown’s categories of cognition,

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related to “soulsh” existence are employed both for their real utility as targets for evaluation and for their theological significance. I will attempt to *intersect* data from relevant disciplines to derive a well-reasoned set of proposals regarding a human “cognitive trajectory.” To do this, I will (1) briefly review the paleoanthropological record, (2) examine cognitive implications of artifacts associated with fossil hominids, (3) review trends in primate brain size and architecture and their implications for hominid fossils and the history of human cognition, (4) address proposals regarding theory of mind and language capacity in ancient hominids, and (5) summarize some strong and weak inferences for a cognitive history of soulsh behaviors.

### The Paleoanthropological Background

The fossil evidence for a long time-depth for human or human-like upright anthropoid primates is now considerable.<sup>14</sup> Figure 1, adapted from several sources, provides a graph of fossil hominid presence through the past 6.5 million years; the figure suggests possible ancestor-descendant relationships for these taxa. Artifacts, which have implications for motor cognition and social organization, in many cases, accompany these fossil occurrences.

A major group of early hominids are the australopithecines, known only from the African continent, and including several species subsumed under three to five genera; *Australopithecus*, *Paranthropus*, *Ardipithecus*, and *Kenyanthropus* are probably stable.<sup>15</sup> While australopithecine pelvises and limbs clearly indicate bipedality, particular features such as curved phalanges are interpreted as evidence for some arboreality, or alternatively, as evolutionary holdovers from arboreal ancestors. Australopithecines have a cranial capacity of around 400–450 cc. They are markedly sexually dimorphic. Australopithecines have been dated back to approximately 5.5 million years before the present (MYBP); incomplete and poorly understood remains occupy time horizons before that benchmark.<sup>16</sup>

Stratigraphic horizons younger than 2.6 MYBP, which contain australopithecines, often include worked stone implements. These are simple flaked cores, often termed “choppers”; many sites also contain the flakes struck from the cores.<sup>17</sup> The tools were originally termed “Oldowan” after the site of

Olduvai Gorge in east-central Africa; but workers are increasingly terming this technology “Mode I.” There is some uncertainty concerning which taxon was responsible for the production of Oldowan-style tools. Cut marks on associated mammalian bones indicate that animals were being scavenged or hunted by the Oldowan tool-makers.<sup>18</sup> The Oldowan technology remains unchanged stylistically up until 1.6 MYBP. There is no good evidence for use of fire by those individuals practicing Oldowan technology.

Hominids assigned to the genus *Homo* are known from stratigraphic horizons dating to about 2.5 MYBP.<sup>19</sup> The earliest forms, like the australopithecines, are known from Africa only and, at present, are assigned to *H. habilis* and *H. rudolfensis*. These earliest representatives of *Homo* are much shorter than modern *Homo sapiens* but possess a somewhat larger mean cranial capacity than that of the australopithecines, averaging 640 cc (range 590 to about 700 cc). *H. habilis*, while bipedal, possess feet which are rotated inward, such that locomotion on the hind limbs would have been extremely “pigeon-toed” and, in fact, not well suited for striding. These earliest representatives of the genus *Homo* may have been the sole creators of the Oldowan tools; at present, direct associative evidence is ambiguous.<sup>20</sup>

Larger-statured representatives of the genus *Homo*, assigned to *H. erectus* (Asia) and *H. ergaster* (Africa) appear in the stratigraphic record about 2 MYBP.<sup>21</sup> These forms approximate the height of modern humans, have body proportions (e.g., shape of pelvis, rib cage, projecting nose) which approximate those of modern humans, and have cranial capacities of between 900 and 1150 cc. The labyrinth of the inner ear attests to identical balancing ability while striding as that of modern humans.<sup>22</sup> Females become relatively larger; sexual dimorphism is greatly reduced. Fossil hominid remains from Dmanisi in Georgia, associated with Oldowan tools and dating to around 1.7 MYBP, resemble *H. ergaster* and document an early presence of *Homo* in south-eastern Europe.

After 1.5 MYBP, the African forms, and succeeding near-Eastern and European forms, are associated with a long-lived stone tool industry termed the “Acheulean,” named for the French site of St. Acheul, originally excavated in 1853. This industry is typified by well-known bifacially-modified

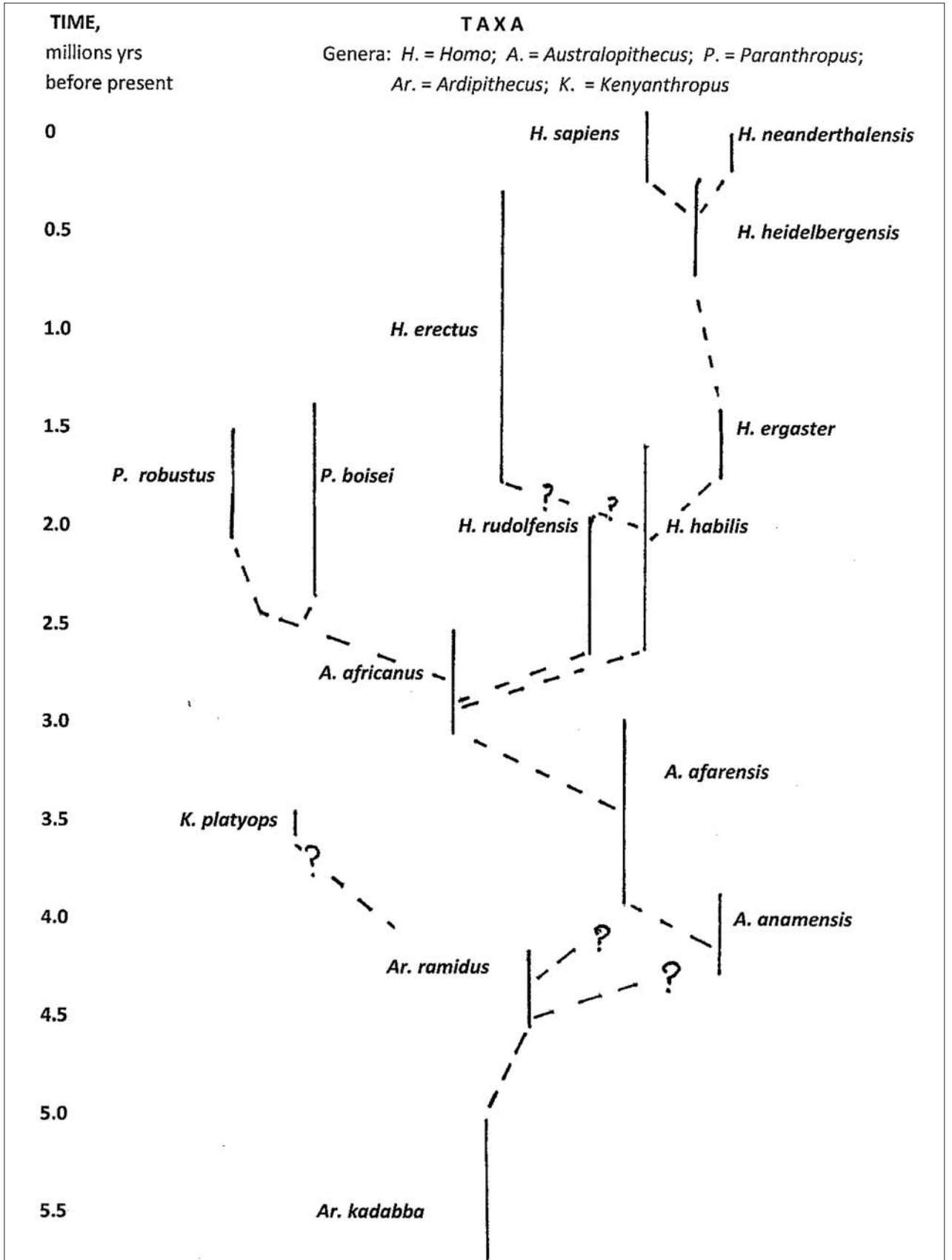


Figure 1. Phylogenetic emplacement of hominid taxa through time.

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“handaxes.”<sup>23</sup> Acheulean-style tools (“Mode II”) persist for over one million years in Africa. East Asian sites from this time period contain few or no handaxes, and the smaller tools are different stylistically from their west Asian/African counterparts.<sup>24</sup>

Hominid skeletal remains dating from 500,000 to 200,000 before the present (BP) are as yet poorly understood. In east Asia, *H. erectus* is the dominant form during this time period. Southern Europe and sub-Saharan Africa exhibit distinct racial varieties with larger cranial capacities than standard *H. erectus*. Very few hominid fossils have been located in Europe prior to 500,000 BP, despite abundant paleontological sites dating from before this time.<sup>25</sup> After that point, early hominids assigned to *H. heidelbergensis*, utilizing Acheulean technology, appear in Europe and rapidly colonize regions north of the Alps and Pyrenees. *H. heidelbergensis* grades through time into the morph *H. neanderthalensis*.<sup>26</sup> Analyses of Neanderthal DNA appear to support the contention that this lineage did not interbreed with the modern-aspect humans which later replaced it in the Middle East and Europe.<sup>27</sup>

The Middle Paleolithic period, defined by technology emergent about 300,000–250,000 BP, is marked by a discontinuance of the production of classic Acheulean handaxes, and the introduction of a more diversified and aesthetic toolkit.<sup>28</sup> Flaking strategies at this point typically involve five to six clearly separable and planned phases; different techniques are applied to different lithic categories. These new tools include blunted, truncated, thinned, or snapped points which were almost certainly modified so as to be hafted; thus these provide the first evidence of “composite tools.” They are sometimes found in contexts which provide evidence of mastery of fire. In Europe and the Near East, these stone tools collectively are termed the “Mousterian Industrial Complex,” and in sub-Saharan Africa, they are assigned to the “Middle Stone Age.” Middle Paleolithic sites are often located in rock shelters or caves; however, evidence for the construction of protective structures is absent. There is little or no real evidence for art or ornamentation.

Neanderthals are interpreted as being “cold-adapted” on the basis of limb proportions and robustness. Their skeletons exhibit much evidence of malnutrition, degenerative joint disease, and repaired bone breakages.<sup>29</sup> They evidently led a rough

life. Neanderthal crania, while shaped differently from those of modern humans, actually possessed slightly higher brain volumes than those of modern humans. Neanderthal populations are often associated with the Mousterian tradition, but early *H. sapiens sapiens* populations also participated in this same tradition. Some Neanderthal burials were deliberate interments.

Humans of modern anatomical aspect, *H. sapiens sapiens*, with modern stature, body proportions, cranial capacities typically in excess of 1300 cc, and reduced faces, appear in the African record around 150,000+ BP, and moved into the Near East around 130,000 BP.<sup>30</sup> Beginning about 110,000 BP, they shared the terrain of the Near East with Neanderthal populations, which were probably migrating southeast from Europe. The two populations coexisted for the next sixty thousand years, both groups employing a similar Mousterian technology. After that time, modern-aspect humans totally replaced the Neanderthals in the Near East. During this interval, the modern-aspect humans developed a distinctive Upper Paleolithic variant technology termed the Aurignacian.<sup>31</sup> After about 60,000 BP, anatomically modern humans with Aurignacian technology moved into Europe and displaced the Neanderthals there. Modern-aspect humans also moved eastward, replacing perhaps a small surviving *H. erectus* population in China and southeastern Asia. Modern humans arrived in Australia prior to 40,000 BP (requiring several boat crossings in open seas of 30 to 90 km), and in North America sometime after 20,000 BP.<sup>32</sup> Demographic profiles of these modern *H. sapiens* demonstrate a clear extension in lifespan to beyond fifty years. Their artifacts exhibit highly aesthetic paintings, carvings, and objects for personal adornment, as well as “luxury” items, such as seashells, which were transported up to hundreds of kilometers from their site of origin.

### A “First Pass”: Artifact-Based Evidence for Cognitive Abilities

The earliest (Oldowan) stone tools are seemingly simple and are definitely monotonous, exhibiting no variability for over one million years. Kimura feels “the Oldowan makers did not seem to have a mental template for a final product, and the other factors such as availability, size, and shape of raw materials would have contributed to the final form of stone

artefacts."<sup>33</sup> On the other hand, their manufacturers possessed a sense for obtaining materials with good fracturing ability, and were able to master techniques which successfully struck off sharp-edged flakes for cutting. The materials, furthermore, were often transported long distances, implying to Semaw "greater mobility, long-term planning, and foresight not recognized earlier."<sup>34</sup> While the choppers or cores do not exhibit a planned ultimate form (template), the blades struck from these may have actually been the goal. These sharpened flakes work well as butchery or plant processing tools.

Today, several West African chimpanzee populations employ stone hammers to crack nuts. The stone hammers, generally igneous rocks or lateritic soil crusts, are carried up to several hundred meters to suitable processing locations (e.g., those possessing a hard surface which can be employed as an anvil upon which to strike).<sup>35</sup> Through use, the hammers become broken; some of these broken flake accumulations mimic the debris associated with production of early hominid tools. Are modern chimpanzees cognitively close to the creators of the Oldowan tools?

In order to ascertain the cognitive implications of Oldowan tools vis-à-vis extant great apes, archaeologists Kathy Schick and Nicholas Toth teamed up with primate psychologists Susan Savage-Rumbaugh, Duane Rumbaugh, and Rose Sevcik to see what the pigmy chimpanzee Kanzi could accomplish when given the opportunity to construct rock tools.<sup>36</sup> In the first stage of the experiment, the use of sharp stone flakes in cutting cords which bound a box containing a food treat was demonstrated to Kanzi. Kanzi readily took up the use of such flakes for cutting, and rapidly learned how to select the sharpest flake out of a set of several presented to him. Next, the technique of breaking a flake off a rock (the "core") was demonstrated. Kanzi quickly took up the habit of splitting off flakes through this percussive technique. However, while his efficiency did improve, he never became adept at mastering the controlled blows at specific angles which the Oldowan tool-makers employed. Chimpanzee wrists and fingers cannot manage the spectrum of modern human grips (see below) and are ill-adapted for fine-scale manipulation. Kanzi eventually learned how to break stones by simply throwing them onto a hard tile floor; over a period of months, this became his technique of choice for creating sharpened

stone implements, rather than direct percussion. Thus, the Oldowan tool-makers clearly evidence *greater spatial foresight*, in relation to manipulative motor cognition, than that possessed by extant apes.

The fact that Oldowan tool manufacture and use require more refined motor cognition than that possessed by pigmy chimpanzees suggests that the tool-makers possessed greater resources in those brain areas devoted to motor cognition: primary motor cortex (M1), supplementary motor cortex (SMA), and premotor cortex (PM).<sup>37</sup> One way to assess the cognitive implications of Mode I technology would be to perform a neuroimaging study of a modern human while the subject was undertaking the manufacture of an Oldowan-style tool. A pilot study of one subject, an experienced flintknapper who is right-handed, was conducted.<sup>38</sup> The pattern of brain activation observed was essentially that expected for a complex motor task requiring hand-eye coordination. Primary motor and somatosensory areas surrounding the central sulcus were strongly activated, including adjacent portions of the SMA. The cerebellum also was activated, as expected for a motor task. Right-handedness was evident in that the primary motor cortex of the left precentral gyrus, as well as the right cerebellum, was preferentially activated. The superior parietal lobes on both sides of the brain were also strongly activated. The superior parietal lobes are association areas involved in complex spatial integration of action and perception. All these areas, including the cerebellum, are greatly expanded in modern humans relative to hominids of two million years or so before the present. Interestingly, prefrontal activation was not noted.

Efficient and safe stone tool manufacture requires anatomical adaptations in the hand which parallel motor cognition investment by the brain. A sizeable body of research into the comparative functional morphology of the hand in fossil and modern humans was initiated by John Napier in the late 1950s and has culminated in classification schemes of various types of grips and associated features by Mary Marzke and co-workers.<sup>39</sup> Of particular note are a suite of special grips which enable the tool-maker to cradle the target stone and firmly pinch the hammerstone, such that tool-making does not expose the hand to damage. Chimpanzee hand morphology cannot sustain the gamut of finessed grips; australopithecine and *H. habilis* hands are

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intermediate in aspect between chimpanzees and modern humans.<sup>40</sup> Muscle attachment scars, relative digit proportions, and the presence of flattened pads in the hands of these early hominids indicate that anatomical reorganization of the hand, correlated to the demands of tool-making, was under way. These structures provide strong evidence that greater areas of somatosensory cortex were being required for manipulative tasks.

Oldowan technique exhibits little change for over one million years. This lack of experimentation and elaboration strongly correlates to the small cranial capacities of the hominids of this period. Several researchers have suggested that the activity of tool-making at the Mode I level, in turn, exerted some sort of Darwinian selective pressure for increased somatosensory cortical mass.<sup>41</sup> Beginning at 1.5 MYBP, the stone tool-makers at Olduvai demonstrate increasing command of percussive technique and more active transport of stone tools; Kimura suggests that this increased technological acumen accompanies the transition to *H. ergaster* in East Africa, with its increased energy needs and expanded foraging strategies.<sup>42</sup>

What of the next major industrial “tradition,” the Acheulean, or “Mode II”? The characteristic form, the classic bifacial handaxe, represents a significant cognitive advance over the Oldowan simple core choppers and derived blades. Schick and Toth feel that “unlike the Oldowan artifacts, which show no definite preconceived shape that their makers were trying to produce, these Acheulean tools show unequivocally that these hominids had specific mental templates of the forms they wanted.”<sup>43</sup> Experimental stone-working over the past century and a half has revealed the sequence of tasks required to form such objects.<sup>44</sup> The handaxe is formed from a prepared blank, chopped out of a larger boulder of brittle, fine-grained rock such as quartzite or flint. The blank is then carefully struck at many angles, symmetrically from both sides, to create the desired end-point object: a sharply pointed cutting instrument with one rounded end accommodating the palm of a human hand, and tapered toward the opposite end from all sides. Final trim to the edge is often accomplished with a hammer formed of softer bone or antler. Experimental usage of handaxes demonstrates that these tools are well suited for animal carcass processing; microscopic analyses of wear patterns on tool edges are also consistent

with butchery. However, at Peninj, Tanzania, one of the oldest known Acheulean sites, blades have been recovered with embedded plant material and microwear patterns suggesting their use in wood-working.<sup>45</sup>

The level of cognition requisite to learn how to create Acheulean tools surely requires significant mental simulation of action, the ability to imitate, and a mental image of a final product (in fact, even contemporary flintknappers take months of apprenticeship to master the techniques of manufacturing Mode II stone tools).<sup>46</sup> Thus, some measure of Brown’s *future orientation* and *top-down processing* criteria for soulsh existence is present in archaic hominids of 1.5 million years or so before the present. On the other hand, Acheulean tools lack explicit symbolism or an aesthetic dimension, such as the rendering of animal or other natural features, or use for personal adornment.<sup>47</sup> Moreover, Acheulean tool forms blend into one another, in contrast to Upper Paleolithic tool forms, which are much more diversified and distinct.<sup>48</sup> Major changes in Acheulean technology were remarkably slow. And the straightforward adaption of stone-working techniques to Acheulean bone tools, rather than the development of techniques better suited to exploit natural bone mechanics, also suggests a lack of foresight.<sup>49</sup>

The Mode II tool-makers were *H. ergaster*/*H. erectus*, as well as earliest *H. sapiens*, with cranial capacities in excess of 1000 cc. Gibson and Jessee suggest that the conjunction of brain size and handaxe technology argues for a modest communicative ability, confined to events, objects, or actions in the immediate environment, which are known to both speaker and viewer.<sup>50</sup> Toth and Schick suggest a test of the language/technology connection: attempt to teach an apprentice or apprentices how to create an Acheulean tool without any verbal discussion (of course, this would take place in subjects with brains much larger than those of the original Acheulean tool-makers, and thus not be an exact re-creation).<sup>51</sup> To my knowledge, no one has yet undertaken such a test. My guess is that a modern human could fairly easily be taught how to manufacture a Mode II tool with little or no verbal instruction.

Middle Paleolithic tools (Mousterian tradition; Middle Stone Age) exhibit more regional variation than that of Lower Paleolithic tools; moreover these

industries include multi-component tools, such as points clearly designed to be hafted to spear shafts, and crafted wooden spears. These cultures also utilized fire, created deliberately paved floors, and, in some sites, buried their dead.<sup>52</sup> All these traits attest to much greater levels of top-down mental processes and planning. Mental templates for design of such instruments are, at this stage, *hierarchical*.

Middle Paleolithic sites also show unequivocal evidence that pigments were applied to objects. However, to date no evidence has emerged that these pigments were used to create symbolic devices, such as paintings or geometric designs. The pigments are applied as smears on tools, and are described by Paul Mellars as “at best perhaps a rudimentary form of aesthetic appreciation.”<sup>53</sup>

Upper Paleolithic industrial complexes include elaborate toolkits. New forms of blade technology appear. Demonstration that some lithic extraction sites were, in effect, economically specialized “quarries,” is much more certain than for the Middle Paleolithic. New and highly significant tools include, for example, fat-burning lamps, as well as bone awls and needles which were used to construct tight fur/skin clothing essential for the colonization of high latitudes, making possible the immigration of humans into the New World across the Bering land bridge.<sup>54</sup> Other new tools include fishhooks and the spear-thrower.

Upper Paleolithic cultures also exhibit many aesthetic aspects. Dwellings such as skin tents exhibit preconceived forms. The archaeological record of the Upper Paleolithic is dense with objects designed for personal adornment; grave sites often include ornaments such as strings of bone or shell beads which are entirely lacking in Middle Paleolithic sites. Naturalistic art in the form of paintings and three-dimensional carved objects of many kinds appeared in profusion during this period. Notably, impossible or novel representations, such as a human carving with a lion’s head, also are common. Such novel representations must have strong cognitive and symbolic implications.<sup>55</sup>

This proliferation of aesthetic objects has been termed the “creative explosion,”<sup>56</sup> the “big bang of human culture,”<sup>57</sup> or the “50,000-year problem.”<sup>58</sup> The dramatic difference(s) between this culture and its predecessors has lured some archaeologists and

cognitive scientists to postulate that, at this point, humans passed some sort of neural and/or social Rubicon, accompanied by significant expansion in the use of symbols, and, hence, perhaps the first true attainment of language.<sup>59</sup> Others see the emergence of art as a more gradual phenomenon, perhaps extending down into the Middle Paleolithic.<sup>60</sup>

## Comparative Primate Neuroanatomy: Overview

Primates, in general, possess large brains with large neocortical regions, relative to other mammals of similar body size.<sup>61</sup> Furthermore, primates possess a unique and extra component to the prefrontal cortex, the lateral prefrontal cortex. The prefrontal cortex is involved in decision-making; the lateral prefrontal cortex appears to be devoted to the “rational” aspect of decision-making.

The brains of *H. sapiens* are absolutely and relatively larger than those of all extant primates; they are three times (absolutely) the size of the brains of extant great apes.<sup>62</sup> However, they are not simply “scaled-up” versions of ape brains; humans have a much smaller primary visual cortex than expected for anthropoids of this body size; human prefrontal regions and the temporal lobes are greatly expanded relative to those of great apes.<sup>63</sup>

With the advent of noninvasive neuroimaging techniques, volumetric and qualitative differences among extant primate taxa can be assessed while brains are intact and operating, as opposed to dead and preserved. A study of forty-four subjects from eleven primate taxa, including humans and all great ape species, has been conducted utilizing MRI.<sup>64</sup> Logarithmic plots of brain volume vs. body weights demonstrate that all nonhuman primate species sampled, including all great apes, fall close to a common regression line; humans are a distinct outlier. Similarly, logarithmic plots of neocortical grey matter volume vs. body weight reveal *H. sapiens* to be a distinct outlier. The human neocortex is 24% (or 115 cc) larger than that predicted by a regression line based on the other ten taxa. Human cerebral white matter is 22% (or 60 cc) larger than expected, based on a regression line for the other ten primate taxa. Human temporal lobes are quantitatively larger than expected for great ape brains scaled up to human size; in particular, temporal lobe white



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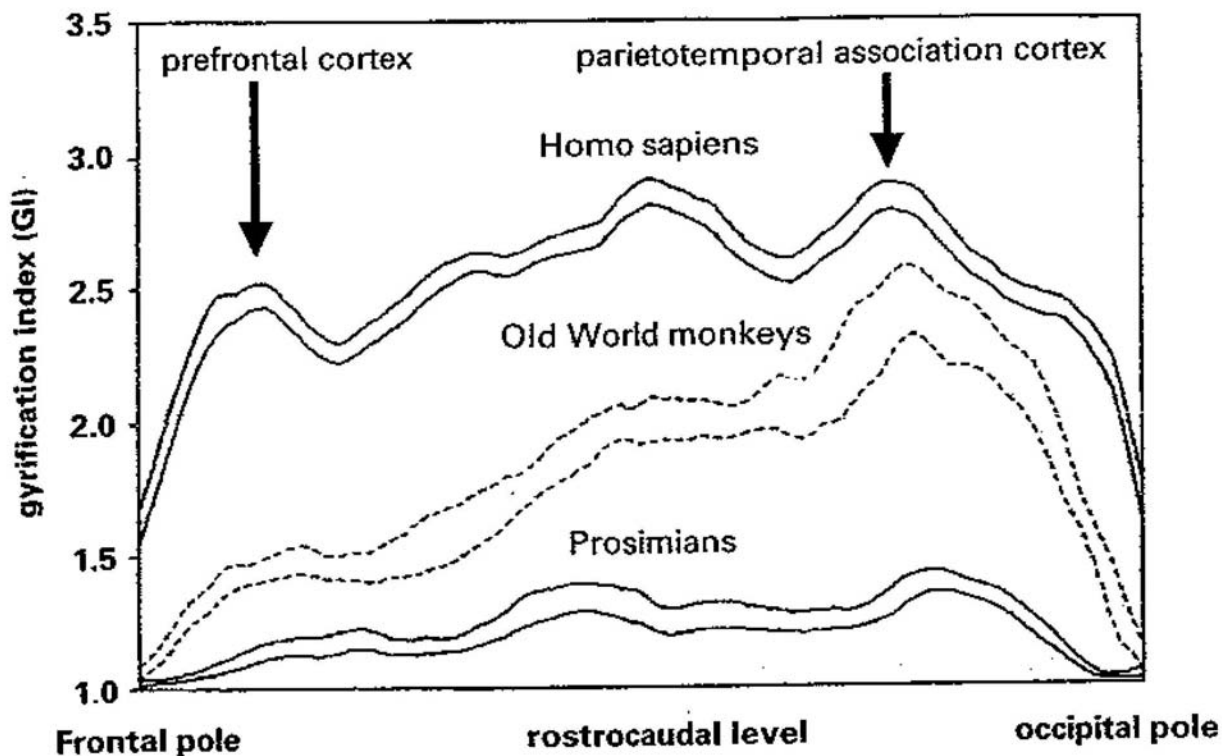
matter is greatly expanded relative to all nonhuman primates sampled.

Brain size expansion in *H. sapiens* dovetails with increases in the development of sulci and gyri relative to other extant primate taxa, a fact long appreciated by comparative neuroanatomists. “Gyrification indices” can be computed, based on a ratio of total length of outer cerebral cortex vs. total length of exposed cortex (only), across serial sections or averaged over the whole brain. In the same MRI study cited above, the squirrel monkey, *Saimiri sciureus*, for example, has a whole-brain gyrification index of 1.56; the orangutan, *Pongo pygmaeus*, the highest nonhuman primate, 2.29; humans, 2.57.<sup>65</sup> The MRI study of gyrification sampled all brains at ten equally spaced coronal “slices”; these revealed that the human prefrontal cortex and the parietal/posterior temporal cortex were more gyrified than expected based on the general whole-brain gyrification. The prefrontal cortex, as already noted, is well understood to be a major site of decision-making and task-management support via working mem-

ory. The parietal cortex is important for spatial representation and attention.<sup>66</sup> A similar study, conducted on twenty-nine different primate taxa, including twenty prosimians, eight Old World monkeys, and humans, again demonstrated large relative increases in gyrification in prefrontal cortical regions and in parietotemporal association cortical regions in humans (Figure 2).<sup>67</sup>

The large volume of human prefrontal cortex, relative to other primates, is paralleled by a significant expansion in human prefrontal cortical white matter. Human white matter anterior to the genu of the corpus callosum was 41% larger than that predicted by nonhuman primate regression of prefrontal white matter vs. nonprefrontal cerebral volume, while on the other hand, human prefrontal gray matter did not differ from predictions.<sup>68</sup> The expansion in white matter corresponds to an increase in intracortical connectivity.

Gross size differences between human and non-human brains are also reflected in differences in



**Figure 2.** Gyrification indices in rostrocaudal sequence for 29 primate species. Gyrification index GI registered in a rostrocaudal sequence in brains of 29 different primate species. The primate species are classified as belonging to prosimians (20 different species), Old World monkeys (8 different species) or *Homo sapiens* (61 individuals). The double curves indicate the 95 percent confidence limits in each group. (Modified after Zilles et al., 1988.) Used by permission from Karl Zilles, “Evolution of the Human Brain and Comparative Cyto- and Receptor Architecture” in *From Monkey Brain to Human Brain: A Fyssen Foundation Symposium*, edited by Stanislas Dehaene, Jean-René Duhamel, Marc D. Hauser, and Giacomo Rizzolatti (Cambridge, MA: The MIT Press, 2005).

noncortical areas of great significance. For example, human striatum volumes are four times those of baboons and twice those of chimpanzees; human hippocampus volumes are three times those of baboons and nearly three times those of chimpanzees.<sup>69</sup> Brain structures in modern humans are “off scale.”

**Learning:** Comparative behavioral studies demonstrate that learning in primates is clearly related to brain size.<sup>70</sup> Functional implications of enlarged brains in humans include those related to procedural learning. Neuroimaging and studies of brain-damaged humans demonstrate that the basal ganglia, cerebellum, and premotor cortex are all implicated in such learning.<sup>71</sup> These structures, enlarged in humans relative to apes and in apes relative to monkeys, are essential for complicated motor activities such as dance, playing of musical instruments, use of complex tools, and so forth, and are also involved in automatic utterances and in writing. The hippocampus, as well as areas of the frontal and temporal lobes which connect to the limbic system, mediates declarative learning as well as emotional contexts for learning.

**Social Play:** The size of both the amygdala and hypothalamus is positively correlated to the percentage of total time spent in social play in non-human primates. A study of twelve primate taxa, including a loris (*Nycticebus*), several New World monkeys, several Old World monkeys, gibbons (*Hylobates*), gorilla, and chimpanzee, regressed percent time observed (by various research teams) in social play against the volumes of these two structures.<sup>72</sup> Social play frequencies and amygdala size were positively correlated and significant at the  $p = 0.005$  level,  $r^2 = 0.69$ . Social play frequencies and hypothalamus size were positively correlated and significant at the  $p = 0.01$  level,  $r^2 = 0.67$ . Nonsocial play frequencies (e.g., object play), on the other hand, were not correlated to amygdala or hypothalamus size. The amygdala is now understood to be a major functional unit in the recognition and generation of emotion. The hypothalamus is a key component of the limbic system, exerting a great control over autonomic function. It is also involved with basic emotions, such as aggression and frustration.

**Language:** Broca’s area, a functional area of unique significance to humans, is an important brain region for the discussion of language and its possible evo-

lution. This region, located on the posterior lateral portion of the frontal lobe, is important for syntactical organization of speech (as opposed to lexical).<sup>73</sup> Patients with the brain-damage syndrome “Broca’s aphasia” understand the meanings of individual words, but have difficulty linking these into syntactic combinations which can readily communicate. However, Broca’s aphasia is not always tied to damage in this region, and many other areas are highly important for speech production and for language comprehension. Nonetheless, for many years, Broca’s area was highlighted in any discussion of the evolution of language, because a well-defined, enlarged (and hence modern-like) Broca’s area can be relatively securely identified on the surface of a fossil brain endocast (see discussion below).

**Motor Activities:** Great apes and humans exhibit greatly expanded cerebellar volumes relative to other primates.<sup>74</sup> The greatly-expanded human cerebellum is often ignored in studies of comparative primate intelligence, because of the more blatant expansion of the cerebral hemispheres. The modern human cerebellum supports a larger and more finessed repertoire of motor activities, including those related to speech production.

## A “Second Pass”: Fossil Hominid Brain Size and Architecture and Cognition

Preserved endocasts of hominid brains are not uncommon. However, because the preservation is coarse-grained, an assessment of gyrification indices has not yet been attempted, and may never be possible. Patterns of gyri and sulci can be discerned but exact interpretation of these as landmarks has been debated (see below).<sup>75</sup> The endocast data have been discussed and argued for many decades, but today are being subjected to new interpretations based on better comparative studies and on neuroimaging data.

The volume of australopithecine brains, determined by endocasts, is about 30% larger than that expected based on a simple regression against body weight for extant apes.<sup>76</sup> Some expansion in cerebral volume relative to extant great apes is apparent. This volumetric increase may correlate to the ability to search out suitable raw materials and to manufacture Oldowan tools; this ability is apparently beyond the capability of extant great apes.

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As noted in the previous section, humans differ from other primates in having a relatively reduced primary visual cortex. In extant primate brains, this is manifest by the position of the lunate sulcus, the anterior boundary of the primary visual striate cortex. The lunate sulcus, a relatively large structure, should be, in principle, visible in fossil hominid endocasts; however, this structure has proven to be highly controversial. Ralph Holloway and coworkers have long defended the notion that this landmark is positioned in australopithecines similarly to that of modern humans, indicating significant reduction of the primary visual cortex and the accompanying reorganization of the australopithecine brain architecture relative to apes, while Dean Falk and coworkers have argued that the position of the lunate sulcus in australopithecines is essentially ape-like.<sup>77</sup> In this article, I accept Glenn Conroy's adjudication, that Falk's diagnosis of the lunate sulcus in australopithecines is correct.<sup>78</sup>

Paleoneurologists agree that the brains of early *Homo* representatives exhibit similarities to those of modern humans. For example, the specimen KNM-ER 1470, a well-preserved early representative of *Homo* (disagreement exists as to species assignment) from East Africa, exhibits a probable Broca's area (unlike australopithecines), and a definite hemispheric asymmetry. While the overall endocast volume is in the 750–775 cc range, the organization is definitely more modern than that of australopithecines.<sup>79</sup>

The brain volumes of *H. ergaster*/*H. erectus*, as determined from endocast data, yet further diverge from those of australopithecines. Unquestionably, some of the brain size divergence is related to an absolute increase in body size, but the brain volume increases more than that predicted by body size alone.<sup>80</sup> Brain volume within *Homo* then increases over the time interval 1.8 MYBP until around 100,000 BP, from around 900 cc to the typical modern value. Neanderthal brain endocasts average slightly larger volumes than modern human brains; their brain architecture does not appear to differ significantly from those of modern humans.

While detailed mapping of fossil external brain structure can be problematic, general proportions and even gross size differences can grant information as to cognition in extinct hominids, when viewed in the light of comparative primate neurobiology.

**Paleoneurology and Learning:** Transfer-of-learning tests are designed to explore the ability of primates to reassess stimuli which previously had been associated with a reward; these are essentially measures of flexibility in learning. Beran and colleagues computed a Spearman rank-order correlation between cranial capacity and transfer index score for twelve extant nonhuman primates, with a value of 0.83.<sup>81</sup> An equation for the best-fit line was determined: Transfer index score = (0.05 x cranial capacity) - 7.2, based on numerical values of transfer index and cranial capacity, not their ranks. This regression equation was then applied to nine extinct hominids belonging to the genera *Australopithecus*, *Paranthropus*, and *Homo*, as well as modern *H. sapiens* (Figure 3).

If the results from application of this regression equation can be trusted, then they can be interpreted as follows: enhancement of transfer learning in *Australopithecus* and *Paranthropus*, two australopithecine genera, exceeded those for all extant primates but still lay close to those of present-day great apes. A jump in transfer of learning is evident in *H. habilis*; a greater jump in *H. rudolfensis*, a greater jump in *H. erectus*, and then an extensive jump up to the levels of *H. neanderthalensis* and *H. sapiens*, with *H. neanderthalensis* actually exhibiting slightly higher values than *H. sapiens*, due to their larger cranial volumes.

I do not believe these estimates of cognition for australopithecines based on brain size to be that far off the mark. They seem to approximate that cognitive level which I would grant based on the Oldowan technology demands.

**Paleoneurology, Social Play and Emotional Modulation:** Studies of the amygdala and hypothalamus, noted above, strongly suggest that fossil hominids with large brains would exhibit significant time spent in social play and greater capacity for Brown's category of “emotional modulation.”

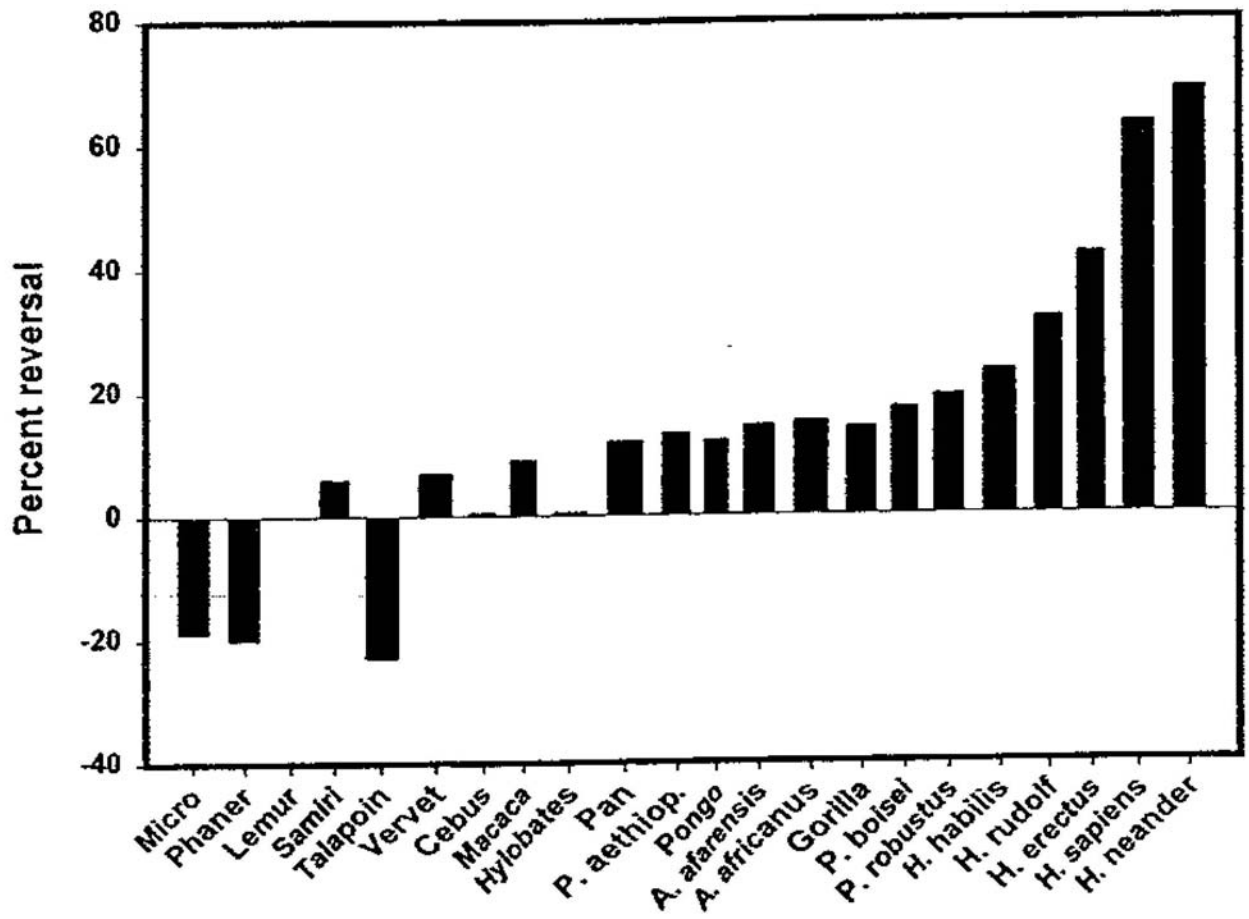
**Language:** The cognitive interpretations for early *Homo* (e.g., *H. habilis*, *H. rudolfensis*, *H. erectus*) based on brain size are intriguing and somewhat uncertain. Several paleoneurologists are willing to consider that *H. erectus*/*H. ergaster* possessed some language capability.<sup>82</sup> Some are willing to grant communicative and learning ability similar to those of modern humans to archaic *H. sapiens* and Neanderthals, extending back to perhaps 200,000 BP.<sup>83</sup> Language is discussed more fully later in this article.

## Inferences as to a “Theory of Mind” in Ancient Hominids

Modern humans dialogue with one another; in the process, they obtain mental representations of the mind of the other individual. These mental representations are also formed on the basis of posture, gesture, facial expression, and other features. Brown claims that the internal representation of the “self” is correlated to this mental representation of another individual’s mind.<sup>84</sup> The belief obtained from these representations, that one is actually interacting with another cognitive being and not a simulacrum or robot, is termed a “theory of mind,” a phrase coined by Premack and Woodruff.<sup>85</sup> It has been argued that at least some measure of a theory of mind is requisite for real language.<sup>86</sup> Brown makes a strong case that this capacity is a prerequisite for relating to God. Can the kinds of evidences previously discussed

provide clues as to a theory of mind in extinct hominids?

Neuroimaging studies have been employed to decompose the interrelated brain activities which undergird a theory of mind in humans. For example, neuroimaging studies demonstrate that, in modern humans, the cells of the posterior superior temporal sulcus (STS) exhibit marked activity when the subject is viewing motions. This region lies anterior and superior to visual area V5, which is activated during perception of motion. Significantly, the STS is also activated during imagination about motions, including goal-direction of actions, and thus the interpretation of actions in other individuals.<sup>87</sup> The anterior paracingulate cortex (ACC), part of the medial prefrontal cortex (MPFC), appears to be a later maturing region during human infant development. The ACC participates in performance



**Figure 3.** Transfer learning ability for thirteen extant primates, including humans; and inferred transfer learning ability for nine extinct hominids, based on brain size. Originally published as Fig.5.2 from chap. 5, “Predicting Hominid Intelligence from Brain Size” by Michael J. Beran, Kathlenn R. Gibson, and Duane M. Rumbaugh, in *Descent of Mind: Psychological Perspectives on Hominid Evolution*, ed. Michael C. Corballis and Stephen E. G. Lea (Oxford: Oxford University Press, 1999), 94. Reproduced with permission.

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monitoring—detecting error and noting reward—and has been shown to be particularly involved in the interpretation of another individual’s subjective internal emotional state.<sup>88</sup>

In an fMRI study of human/computer vs. human/human interactive game-playing, both protocols were accompanied by responses from the STS and ACC, but the human/human interactive version also elicited a strong response from the posterior cingulate and the hypothalamus, which are often associated with emotionally salient stimuli, and with the hippocampus, involved in episodic memory.<sup>89</sup> Thus, in humans, the theory of mind relies on a multiplex of interacting systems, connecting memory of past events and states, emotion, and the interpretation of postures, motions, facial expressions, and the like in other individuals.

fMRI studies on macaques demonstrate that both the STS and the frontal cortex area F5 are activated when motions are observed in other individuals.<sup>90</sup> These fMRI studies include motion-occlusion experiments in which an individual moves across the field of view, is temporarily occluded by an object, and then re-emerges on the other side. Thus, the same neurobiology is employed to follow and anticipate motion in macaques as in humans. But this is far from establishing that monkeys also follow another’s subjective internal state.

Observations and experiments, in fact, have failed to demonstrate the presence of a theory of mind in monkeys. Tests for a theory of mind, often termed “Sally-Anne” tests, have been devised to ascertain expectations based on false beliefs concerning the state of another mind.<sup>91</sup> “Sally” and “Anne” are actor-researchers observed by an experimental subject. “Sally” places an object in one position in a room and then leaves the room for a time. During the time she is absent, “Anne” moves the object. When “Sally” returns, will the experimental subject expect “Sally” to go to the new position, or to the old? In humans, individuals with autism and children under four years of age will predict that “Sally” will search in the new position; these individuals are hypothesized to lack a theory of mind, because they do not realize that “Sally” would intend to return to the original site. Such tests, applied to macaques, utilize the gaze of the subject animal as the response, rather than a verbal prediction.<sup>92</sup> Thus far, these studies provide no evidence that the monkey

understands the mental state of the observed individual. Years of behavioral observation on vervet monkeys and baboons in the wild also find no evidence for the presence of a theory of mind.<sup>93</sup>

Apes such as chimpanzees, in contrast to monkeys, exhibit at least a rudimentary theory of mind.<sup>94</sup> Chimpanzees not only follow another individual’s gaze, but will do so past distractors. If chimps cannot perceive just what the other individual is staring at, they will double-check on the direction of gaze. Furthermore, chimpanzees will utilize information about another individual’s gaze to conceal their approach to contested food items.<sup>95</sup> Chimpanzees also may quiet or suppress normal vocalizations in certain social situations, e.g., when hunting in a group. Apes demonstrate consolative behaviors such as comforting gestures by individuals uninvolved in a conflict. Apes, as opposed to monkeys, recognize their visage in a mirror and react to marks surreptitiously placed on their brow, indicating a degree of self-perception. Chimpanzees taught basic sign languages have, in turn, spontaneously taught other chimpanzees; this teaching activity included physically molding the novice chimp’s hands to form signs.<sup>96</sup>

If extant apes, in general, possess a rudimentary theory of mind, then it is both phylogenetically parsimonious and neurobiologically sound to propose that the australopithecines, with their higher relative brain volumes, also possessed at least a rudimentary theory of mind. Therefore, some scenarios for hominid evolution explicitly begin with a theory of mind and some sort of attendant social grouping behaviors, which set the stage for a relatively early blossoming of language and culture.<sup>97</sup>

Simon Bar-Cohen, however, doubts whether hominids prior to the “creative explosion” circa 50,000 BP possessed a theory of mind. He lists eight classes of behaviors which require a theory of mind, including the following: intentionally communicating with others, repairing failed communication with others, teaching others, intentionally sharing a focus or topic of attention, and pretending. Bar-Cohen looks at autism in humans as a (devastating) lack of theory of mind.

Children with autism also show us how useless a language capacity is without a theory of mind. Strip out a theory of mind from language use and you have an individual who might have

some syntax, the ability to build a vocabulary, and a semantic system. Crucially, what would be missing from their language use and comprehension is “pragmatics” – being able to decipher the speaker’s communicative intentions, decipher non-literal language, read “between the lines,” understand jokes, and tailor one’s speech to fit the listener’s background mental states.<sup>98</sup>

I find Bar-Cohen’s suggestions to be of mixed value. Certainly there is very limited evidence, if any, that primates in the wild purposively teach. Dorothy Cheney and Robert Seyfarth note, “Evidence for teaching by nonhuman primates, however, can be summarized by one word: scant.”<sup>99</sup> However, chimpanzees taught how to use manual signs do intentionally communicate with humans. Bar-Cohen’s use of autism as an example of language without a theory of mind puzzles me. While all view the phenomenon of autism as tragic, most of us would consider an autistic individual to be a damaged human being and not a nonhuman. On the other hand, perhaps this diminishment of cognitive ability gives us an insight into the cognitive world of past hominids with less-developed theories of mind. And, perhaps, communication (rudimentary language) over hominid history fostered a theory of mind.

In humans, teaching is, indeed, crucial. Teaching is necessary for cultural transmission and is certainly dependent on a theory of mind.<sup>100</sup> Teaching in modern humans, of course, includes the transmission of complex symbolic knowledge, including religious knowledge. I suggest that this ability, interlinked with language and a theory of mind, is a signal cognitive capacity characteristic of human soulful behavior.

## The Emergence of Language

Teaching in humans involves rapid transmission of large quantities of cultural data, achieved through the medium of language. Human language is decomposable, cognitively, into three aspects or capacities: (1) lexical capacity; (2) morphological and syntactical processing, which organizes words into meaningful combinations; and (3) phonetic and phonological processes, which produce the sounds of speech.<sup>101</sup> Because these three aspects afford different types of clues in ancient hominids, I will examine each category separately.

**Lexical Capacity:** The dictionary or lexicon of the brain has been revealed by neuroimaging studies to be composed of distributed and overlapping neural networks. These networks are semantic in nature, that is, they call up various relationships between concepts when words are pronounced or imagined. Human brain areas activated during word recall include, for example, perception and motor areas associated with the object or action. The recall of the word “hammer,” for instance, will cause activation of the primary sensorimotor cortex associated with gripping and using a hammer.<sup>102</sup> This phenomenon is also demonstrated in category-specific impairments, in which damage to specific brain regions affects entire categories of words (e.g., “animals”), because of semantic regionalization.<sup>103</sup> As most of the distributed neural lexical networks reside in cortical tissue, the lexicon can be tied, historically, to cortical size. If, for example, evidence could be provided that vervet monkey alarm calls, which are discreet for predator type, involved distributed neural networks, then these could be construed as “words.”<sup>104</sup> However, because vervets possess much smaller cortical area than humans, their lexicon must have severe restrictions. Chimpanzees reared in human environments can be taught many dozens of signs. Because their employment of signs in combinations demonstrates semantic relationships, for example, the ability to respond to “who?” or “what?” questions, these signs are considered herein as lexical items.<sup>105</sup>

Thus, a preliminary working hypothesis might be that simple expansion of brain size, and particularly of the neocortex, during hominid history, gradually gave greater scope for lexicons. Cortical connections to the hippocampus would also be highly significant.

**Speech production:** Speech production per se is much more significant than many theorists have proposed, because of motor-cognitive skills which are interconnected to many brain circuits. An enormous number of modulated muscle combinations act to change the shape of lips, move the tongue, control inspiration/expiration, and change the shape of the vocal folds. Notably, these implicate the cerebellum. The cerebellum is expanded in apes relative to monkeys and exhibits expansion during hominid history. The primary motor cortex also includes large areas for the direction of facial muscles; notably, the laryngeal control cortex is adjacent to that

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for the lips and tongue.<sup>106</sup> Thus, expanded cortical regions, including supplementary motor cortex and premotor cortex, make available many more combinations of positions in the above subcomponents. These motor patterns take time to fully develop during growth. In fact, in modern humans, full motor ability for pronunciation is actually not reached until ten years of age.<sup>107</sup>

Because speech production by itself is very significant, it allows for a class of analyses which can actually be performed on fossil skeletons: comparative morphometric examinations of vocal tract shapes and sizes. The configuration of the neck relative to the skull base, the shape of the palate, and prognathism and mouth size can be scaled against those of chimpanzees and/or humans to judge whether the physical speech apparatus in a given taxon resembled those of apes or that of humans. Measurements of mandibular length and height, the height of the cervical spine, and the hyoid apparatus have been combined for samples which include chimpanzees; Neanderthals; a specimen of *H. ergaster*; Skhul V, which is an early anatomically modern *H. sapiens* from the Levant; other modern humans from the Upper Paleolithic; and contemporaneous humans.<sup>108</sup> Reconstructed proportions of the supralaryngeal vocal tract for the *H. ergaster* specimen were within the range of modern chimpanzees. The neck lengths for the Neanderthal skeletons were within the lower range of modern humans, but their oral cavities were longer. These features and some others indicate that Neanderthals could not create the full gamut of sounds which modern humans can, but this, by no means, rules out speech per se.

The human supralaryngeal vocal tract is constructed so as to favor speech, but at the cost of permitting choking. A Darwinian-style explanation for its persistence in hominid history, therefore, explains the origin of a *H. sapiens*-style vocal tract as an adaptation following the introduction of some sort of speech. The advantage provided by the communication outweighed the occasional death caused by choking.<sup>109</sup> On this scenario, perhaps tenuous, the case is made that *H. ergaster* possessed some sort of linguistic capability which in turn, over millennia, exerted a selective pressure for the development of the fully modern human supralaryngeal vocal tract.

**Syntactical Thinking and Language:** The phenomenon of hierarchical syntactical organization, such that language may generate nearly infinite meaningful combinations, is often claimed as the absolute distinguishing unit between human spoken communication and the verbalizations of other animals.<sup>110</sup> Chimpanzees taught nonvocal communicative techniques do exhibit extremely simple but real syntactical combinations.<sup>111</sup> However, a vast difference exists between these extremely short symbolic combinations and those of human syntax.

Philip Lieberman has championed the role which subcortical structures play in syntax.<sup>112</sup> In recent decades, CT scans and MRI have demonstrated that permanent loss of language involved in Broca's aphasia does not occur unless the damage extends to the subcortical areas. Subcortical structures such as the putamen and the thalamus have connections to the anterior cingulate cortex and dorsolateral prefrontal cortex. These subcortical structures perform important switching functions, and they mediate emotive significance to sentences.

### Summary: Linguistic Capacity through Time

Intersected data from the fields of psycholinguistics, primate (including human) neuroanatomy and vocal tract anatomy, fossil hominid brain endocasts, and fossil cognates of vocal tract anatomy argue for the following historical propositions concerning the structural, neurological, and behavioral emergence of human language ability:

1. Australopithecines possessed lexicons similar to those of extant chimpanzees, but probably of slightly greater scope or finesse. However, like chimpanzees, their ability to communicate employing this lexical capacity was restricted by their vocalization abilities. They possessed a rudimentary theory of mind. Their brains, while relatively larger than chimpanzees, are small and lack a human-like Broca's area, indicating very limited syntactical ability; their technology also supports the notion that hierarchical thinking processes were minimal.
2. Broca's area is present in early *Homo*. Although it should not be presumed to confer modern-style speech, presumably it supported syntactic thinking, promoting syntactic communication.
3. *H. ergaster*/*H. erectus* possess a mid-range brain volume, around 1000 cc, with greatly expanded cortical regions. Assuming that connectivity follows cor-

tical volumes, these would certainly provide much greater lexical scope, and greater verbal motor control. Verbal communication would have been significant. Their technology, while supporting a thesis that these creatures planned, does not evidence much hierarchical thinking—a requisite for modern-style syntax.

4. The development of the suites of mimetic and social activity required for constructing and using Acheulean tools fostered greater flexibility in behavior patterns, including communicative patterns.<sup>113</sup>

5. The survival advantage granted by this more fluid and more specific vocal communication neurological-behavioral suite (larger lexicons, hierarchical-syntactic capability, mimetic behaviors), in terms of information transfer, would then permit greater applications. These would, of course, be interconnected with greater insight into other individuals' intentions and internal states (theory of mind) and greater environmental insight.<sup>114</sup>

6. Carried through to a logical end-point, this would result in the phenomenon of verbal instruction, with

7. the possibility of a complex symbolic culture.

## A Cognitive Evolutionary Trajectory for Soulful Behaviors

Clues of diverse sorts testify to cognitive abilities of long-dead hominids. For example, biomechanical studies of small-scale structures in the hominid hand can, in turn, contribute to inferences as to the volume of somatosensory and motor cortex devoted to manipulation. Such clues may be blatant, but many are subtle. The revitalized field of cognitive psychology is today providing tools which enable reinterpretation of many of the "classic" symptoms of cognition, such as blade technology. Moreover, this new cognitive science provides us with a set of cognitive categories which are of much greater utility in the search for the human in these ancient hominids. These categories include those outlined by Brown and employed here.

I do not find inferences as to cognition in australopithecines to be problematic. These taxa were bipedal (but inefficiently so), which is surely significant for their ecology and lifeways. They possessed brains with volumes slightly larger than expected for their body size when compared to those of modern great apes. The brain volumes of australopith-

ecines, however, suggest that they possessed little flexibility in learning. Interpretations of sulcal patterns on fossil brain endocasts of australopithecines are not resolved but may yet reveal that some modest architectural reorganization was occurring.

The creators of the Oldowan tools possessed an elevated motor cognition relative to that of extant apes, and also transported the requisite rock types much greater distances than do modern chimpanzees who employ rocks to crack open food items. This indicates a somewhat elevated ability to plan—what Brown termed "future orientation." The marked sexual dimorphism of australopithecines argues for a very different social organization than that of modern humans, possibly a polygynous one similar to that of modern gorilla troop organization.<sup>115</sup> This surely has implications for Brown's category of "emotional modulation." Parsimony suggests that australopithecines, like modern great apes, possessed a theory of mind, at least at a rudimentary level. However, evidence outlined above strongly argues that language was absent. The australopithecines possessed a small, yet real, kernel of the capacities which Brown proposed as the cognitive substrate for soulful behaviors, but from a psychological or cultural standpoint, the australopithecines were far removed from modern humanity.

It is possible that the manufacture and use of stone tools set in motion a recursive reinforcement for better motor control; individuals with greater motor resources (including those of the cerebellum) might have possessed some selective advantage. Because those same motor areas relate to speech production, this, in turn, would have fostered vocal control.<sup>116</sup> This notion circles back to that of an earlier generation of anthropologists, who put great stress on tool-making as the hallmark of humanity.<sup>117</sup>

Early *Homo*, presently classified as *H. habilis* and *H. rudolfensis*, while still short-statured, possessed brains up to 50% greater in volume than those of the australopithecines. Forebrain expansion is evident, including prefrontal cortex, and a plausible claim can be made that a Broca's area is present in early *Homo*. The mere presence of a Broca's area need not imply a speech system with the flexibility and open-endedness of modern language; brain volumetrics strongly suggest limited lexical ability in comparison to modern humans. However, if the extrapolation/interpolation method for estimating



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learning flexibility, as developed by Rumbaugh and colleagues, yields even somewhat accurate results, then we can assert that these creatures possessed much greater learning flexibility than that of extant apes.

With general brain expansion and expanded prefrontal cortex, early *Homo* would have possessed a much more nuanced theory of mind as compared to modern apes or australopithecines. Expansion in the sizes of the amygdala and hypothalamus would lead to greater emotional modulation of behavior and communication. Expansion of the hippocampus would lead to greater memory ability and better planning. We can infer that these capacities were interlinked; progressive efficiency in any one of these capacities would influence the others. However, it is doubtful that these abilities would as yet achieve levels which Brown’s schema would classify as requisite for soulsh behavior. These taxa will remain somewhat puzzling because we do not have good contemporary analogs for organisms at their level of cognition.

The forms *H. erectus* and *H. ergaster* are intriguing and problematic, partially through lack of some categories of evidence, and partially through the abundances of some kinds of evidence! The brains of these creatures range from 850 cc to 1150 cc; thus, the upper fringe of brain volumes overlaps that of the lower fringe of contemporary humans. Expanded brain temporal regions would provide greater association areas and, hence, greater lexical capacity.

The Acheulean toolkit, while monotonous and conservative for over a million years, exhibits a preference for symmetry and requires motor skills and hand functional morphology approaching those of modern humans. As Schick and Toth note, it takes weeks or months for a contemporary apprentice flintknapper to learn how to efficiently (and safely) create such superior cutting instruments. Assuming there were *H. ergaster* “apprentice flintknappers,” these need not have been instructed primarily by spoken words; they could have learned their technique mainly through visual inspection, imitation, and experimentation. Brains of this size would even permit automation of tool-making behaviors. Perhaps *H. ergaster* tool-makers thought of lunch or planned to play with the children while they honed their Mode II tools.

*H. erectus* is the name given to this hominid grade in southeastern Europe, China, and southeastern Asia. Whether the hominids assigned to *H. erectus* are regional races of *H. ergaster* or not, some sort of migration out of Africa occurred. However, these creatures were not able to penetrate colder latitudes. They evidently lacked cultural resources to survive intense winters. This may or may not have cognitive implications; many contemporary hunter-gatherer groups in the tropics may lack cultural resources to survive intense winters.

Some scientists who have pondered the prehistory of the mind (e.g., Mithen, Deacon, Klein, Holloway) are willing to hypothesize that “mid-grade” hominids such as *H. ergaster* possessed a great deal of perishable or ephemeral culture and some degree of flexible vocal communication; others (Bar-Cohen, Walker and Shipman, Mellars, Davidson and Noble) believe these forms to be quite mentally and culturally deficient by our standards. The usual sticking points seem to be the absence of regional stylistic variation in Mode II technology and the absence of aesthetic objects. Significantly for Christian theorists, there is no evidence for religious practice. All workers, Christian and non-Christian, could make a better judgment call if they were permitted to resurrect a few *H. ergaster*, and watch them interact and live out their lives.

Hominids of the Middle Paleolithic have brains much closer in size and organization to those of modern humans. They moved into colder regions and their sites evidence the use of fire. Regional technological variations blossomed.

Hominids of modern anatomical aspect first appeared in Africa more than 150,000 BP. They subsequently migrated out and displaced contemporary hominids in southern Europe and in eastern Asia, transitioning into an Upper Paleolithic culture along the way. They continued their migrations into Northern Europe, to Australia, Northern Asia, and ultimately, into the Americas. Upper Paleolithic toolkits include many complex implements, which require hierarchical thinking and future orientation for their planning and production. Aesthetic objects, including objects of adornment, became common. Graves are accompanied by objects indicating respect for the departed or a sense of bereavement, or both. Some aesthetic objects are interpreted as

evidence for shamanism. These hominids are judged by most workers to be as modern in their cognitive abilities.

## Postscript: Antique Hominids and the Image of God

The notion that humans have been created in God's image is a significant item of faith for all Christians.<sup>118</sup> Theological evaluations of fossil hominids (whether or not the evaluators accept human evolution from nonhuman anthropoids) typically have been framed in a manner designed to present a criterion or criteria from which to assess the presence or absence of the *imago Dei*. The proposed test criteria usually include such items as cave art or other evidences of an aesthetic sense; evidences of care of injured or ill individuals; burial or other evidences of a belief in an afterlife. Such evidences certainly exist in the ancient record, but many other kinds of clues are present as well. The totality of the evidences, plus a set of search images informed by modern cognitive and neurobiological studies, provide a much more nuanced picture of the emergence of humanity and may even help us to understand the nature of the "image of God" in humans.

Classically, Christian theology holds that the image of God consists of various capacities, such as rationality or a moral sense, which are uniquely possessed by humanity. However, it is clear that such capacities underlie functions or roles which humans exercise. Vocational definitions of the *imago Dei* have been proposed by Verduin, Horton, and Middleton, among others.<sup>119</sup> For example, Richard Middleton's well-argued thesis that the "image" of God actually corresponds to an appointed office might offer some help in the resolution of difficulties with the hominid fossil record. This office is "a commission to extend God's royal administration of the world as authorized representatives on Earth."<sup>120</sup>

If the *imago Dei* represents an elective act by the Almighty God to a representational office, based on a cognitive platform designed over time, then may we be permitted to speculate when this appointment occurred?<sup>121</sup> I feel that the common tendency for Christians and non-Christians to focus on a few dramatic benchmarks, such as the eruption of cave art in southern Europe 40,000 BP (the "creative explosion"), misses some more basic, but humble,

markers of a significant cognitive platform. For example, Middle Paleolithic culture is typified by the use of fire, multicomponent tools, regional variation in tool production, and human burial. Another potential benchmark might be the origination of anatomically modern humans. A third possibility would be the beginning of Upper Paleolithic culture. Perhaps it is not within our power to discern.

If the Christian accepts, as a working hypothesis, that humans are connected genealogically to other primates and that we understand something of the history of this connectivity by way of the fossil record, then many types of evidences become available to elucidate stages in the erection of a cognitive platform for both soulfulness and the ultimate commission as God's regents on Earth. Brown's categories of cognition, which function here as targets for analysis, will continue to prove to be extremely useful, whatever one's perspective may be on the nature of the soul.

Human beings have been blessed with amazing cognitive abilities which enable us to relate to one another, to exercise stewardship over creation, and to seek our Creator. However, we still see dimly, as through a glass. We look forward to the New Creation, where God will dwell in our midst and no one will require instruction from a neighbor of God. ✎

*"The signature on each soul  
may be a product of  
heredity and environment,  
but that only means that  
heredity and environment  
are among the instruments whereby  
God creates a soul."*

— C. S. Lewis<sup>122</sup>

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### Notes

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<sup>2</sup>Stephen J. Gould, *Wonderful Life: The Burgess Shale and the Nature of History* (New York: W. W. Norton, 1989), 44.

<sup>3</sup>Margaret T. Hodgen, *Early Anthropology in the Sixteenth and Seventeenth Centuries* (Philadelphia, PA: University of Pennsylvania Press, 1964); David N. Livingstone, *Adam’s Ancestors: Race, Religion and the Politics of Human Origins* (Baltimore, MD: Johns Hopkins University Press, 2008).

<sup>4</sup>T. Burnet, *The Sacred Theory of the Earth: Containing an Account of the Origin of the Earth, and of All the General Changes Which It Hath Already Undergone, or Is to Undergo, till the Consummation of All Things* (London: R. Norton for Walter Kettilby, 1684–1690), 272.

<sup>5</sup>Livingstone, *Adam’s Ancestors*.

<sup>6</sup>John C. Greene, *The Death of Adam* (Ames, IA: Iowa State University Press, 1959); Raymond Corbey, *The Metaphysics of Apes: Negotiating the Animal-Human Boundary* (Cambridge: Cambridge University Press, 2005); see also Thomas Henry Huxley, *Man’s Place in Nature* (1863; reprint, Ann Arbor, MI: University of Michigan Press, 1959). During the 1980s as a member in an adult Sunday School class, I observed a guest lecturer firmly explain that “humans are not mammals.”

<sup>7</sup>Carolus Linnaeus, *Systema Naturae, sive Regna Tria Naturae, Systematice Proposita per Classes, Ordines, Genera, et Species* (Leyden and London: Theodore Haak, 1735).

<sup>8</sup>Linnaeus, *Systema Naturae*, 12th ed. (Stockholm, 1766). I owe the source of this quote to Greene, *The Death of Adam*.

<sup>9</sup>Cf. Huxley, *Man’s Place in Nature*; Ernst Haeckel, *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1868), translated as *The History of Creation* (London: Kegan Paul, Trench, and Co., 1868); Charles Darwin, *The Descent of Man and Selection in Relation to Sex*, 2d rev. ed. (London: Murray, 1874); Donald K. Grayson, *The Establishment of Human Antiquity* (New York: Academic Press, 1983); Corbey, *The Metaphysics of Apes*; Livingstone, *Adam’s Ancestors*.

<sup>10</sup>Cf. Rita Carter, *Mapping the Mind* (Berkeley, CA: University of California Press); Antonio Damasio, *The Feeling of What Happens* (New York: Harcourt Brace and Company, 1999); Carl Zimmer, *Soul Made Flesh: The Discovery of the Brain and How It Changed the World* (New York: Free Press, 2004); Edward E. Smith and Stephen M. Kosslyn, *Cognitive Psychology: Mind and Brain* (Upper Saddle River, NJ: Pearson Prentice Hall, 2007).

<sup>11</sup>Cf. the many papers in Brown, Murphy, and Maloney, eds., *Whatever Happened to the Soul?* Robert John Russell, Nancey Murphy, Theo C. Meyering and Michael A. Arbib, eds., *Neuroscience and the Person: Scientific Perspectives on Divine Action* (Berkeley, CA: The Center for Theology and the Natural Sciences, 1999); Jeeves, ed., *From Cells to Souls – and Beyond*; Richard S. Lints, Michael S. Horton, and Mark R. Talbot, eds., *Personal Identity in Theological Perspective* (Grand Rapids, MI: Eerdmans, 2006), among others.

<sup>12</sup>For excellent statements of contrasting views on the nature of the soul, I refer the reader to John Cooper, *Body, Soul, and Life Everlasting: Biblical Anthropology and the Monism-Dualism Debate* (Grand Rapids, MI: Eerdmans, 1989); Joel Green, “What Does It Mean to Be Human?” in *From Cells to Souls – and Beyond*, ed. Jeeves, 179–98; and Joel Green, *Body, Soul, and Human Life* (Grand Rapids, MI: Baker Academic, 2008), and the several position papers in Joel Green and Stuart L. Palmer, eds., *In Search of the Soul: Four Views of the Mind-Body Problem* (Downers Grove, IL: InterVarsity Press, 2005).

<sup>13</sup>Brown, “Cognitive Contributions to Soul”; Brown, “Evolution, Cognitive Neuroscience, and the Soul”; Brown, “Neurobiological Embodiment of Spirituality and Soul.”

<sup>14</sup>Michael H. Day, *Guide to Fossil Man*, 4th ed. (Chicago, IL: University of Chicago Press, 1986); Glenn C. Conroy, *Reconstructing Human Origins: A Modern Synthesis* (New York: W. W. Norton, 1997); Richard Klein, *The Human Career: Human Biological and Cultural Origins* (Chicago, IL: University of Chicago Press, 1999); David W. Cameron and Colin P. Groves, *Bones, Stones, and Molecules: “Out of Africa” and Human Origins* (Amsterdam: Elsevier Academic Press, 2004); Jeffrey H. Schwartz and Ian Tattersall, *Terminology and Craniodental Morphology of Genus Homo (Europe)*, *The Human Fossil Record*, vol. 1 (New York: Wiley-Liss Publishers, 2004); Schwartz and Tattersall, *Craniodental Morphology of Genus Homo (Africa and Asia)*, *The Human Fossil Record*, vol. 2 (New York: Wiley-Liss Publishers, 2004); Schwartz and Tattersall, *Craniodental Morphology of Early Hominids (Genera Australopithecus, Paranthropus, Orrorin) and Overview*, *The Human Fossil Record*, vol. 4 (New York: Wiley-Liss Publishers, 2004); Donald Johanson and Blake Edgar, *From Lucy to Language*, rev. ed. (New York: Simon and Schuster, 2006); G. J. Sawyer, Viktor Deak, Esteban Sarmiento, and Richard Milner, *The Last Human: A Guide to Twenty-Two Species of Extinct Humans* (New Haven, CT: Yale University Press, 2007).

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- <sup>16</sup>*Ibid.*; also Ann Gibbons, *The First Human* (New York: Doubleday, 2006).
- <sup>17</sup>Cf. Mary D. Leakey, *Excavations in Beds I and II, 1960–1963, Olduvai Gorge*, vol. 3 (Cambridge: Cambridge University Press, 1971); J. Desmond Clark, "The African Origins of Man the Tool-Maker," in *Human Origins: Louis Leakey and the East African Evidence*, eds. Glynn L. Isaac and E. R. McCown (Menlo Park, CA: W. A. Benjamin, Inc, 1976), 1–54; Kathy D. Schick and Nicholas Toth, *Making Silent Stones Speak: Human Evolution and the Dawn of Technology* (New York: Simon and Schuster, 1993); Nicholas Toth and Kathy D. Schick, "Early Stone Industries and Inferences Regarding Language and Cognition," in *Tools, Language and Cognition in Human Evolution*, ed. Kathleen R. Gibson and Tim Ingold (Cambridge: Cambridge University Press, 1993), 346–62; Sileshi Semaw, "The World's Oldest Stone Artefacts from Gona, Ethiopia: Their Implications for Understanding Stone Technology and Patterns of Human Evolution between 2.6–1.5 Million Years Ago," *Journal of Archaeological Science* 27 (2000):1197–214; Stanley Ambrose, "Paleolithic Technology and Human Evolution," *Science* 291 (2001): 1748–53.
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- <sup>97</sup>E.g., Mithen, *The Prehistory of the Mind*.
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# Article

## Assessing Evidences for the Evolution of a Human Cognitive Platform for "Soulful Behaviors"

- <sup>102</sup>Alex Martin, "Organization of Semantic Knowledge and the Origin of Words in the Brain," in *The Origin and Diversification of Human Language*, ed. Jablonski and Aiello, 69–88.
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- <sup>105</sup>Cf. the many papers in Gardner, Gardner, and Van Cantfort, eds., *Teaching Sign Language to Chimpanzees*; Rumbaugh and Washburn, *Intelligence of Apes and Other Rational Beings*.
- <sup>106</sup>F. Netter, *Nervous System*, part I, "Anatomy and Physiology," The CIBA Collection of Medical Illustrations, vol. 1 (West Caldwell, NJ: CIBA Pharmaceutical Company, 1983).
- <sup>107</sup>Lieberman, *Toward an Evolutionary Biology of Language*.
- <sup>108</sup>McCarthy et al., in submission, as reported in Lieberman, *Toward an Evolutionary Biology of Language*.
- <sup>109</sup>This exact line of argument is followed by Steven Pinker, "The Evolution of the Human Language Faculty," in *The Origin and Diversification of Human Language*, ed. Jablonski and Aiello, 117–26; and Lieberman, *Toward an Evolutionary Biology of Language*.
- <sup>110</sup>Stephen R. Anderson, *Doctor Doolittle's Delusion: Animals and the Uniqueness of Human Language* (New Haven, CT: Yale University Press, 2004).
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- <sup>113</sup>Merlin Donald, "Preconditions for the Evolution of Protolanguages," in *The Descent of Mind*, ed. Corballis and Lea, 138–54.
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- <sup>117</sup>For example, Sherwood Washburn. See Wilson, *The Hand: How Its Use Shapes the Brain, Language, and Human Culture*.
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- <sup>119</sup>Verduin, *Somewhat Less than God*; Horton, "Image and Office"; J. Richard Middleton, *The Liberating Image*. See also a vocational view of humanity in John Murray, "Man in the Image of God."
- <sup>120</sup>Middleton, *The Liberating Image*, 289.
- <sup>122</sup>For helpful discussions on when and where the origination of the first creatures bearing God's image occurred, see Bernard Ramm, *The Christian View of Science and Scripture* (Grand Rapids, MI: Wm. B. Eerdmans, 1954); Davis A. Young, "The Antiquity and Unity of the Human Race Revisited," *Christian Scholar's Review* 24 (1995): 380–96; James P. Hurd, "Hominids in the Garden?" in *Perspectives on an Evolving Creation*, ed. Keith B. Miller (Grand Rapids, MI: Wm. B. Eerdmans, 2003); Peter Rüst, "Early Humans, Adam, and Inspiration," *Perspectives on Science and Christian Faith* 59 (2007): 182–93; Deborah B. Haarsma and Loren D. Haarsma, *Origins: A Reformed Look at Creation, Design and Evolution* (Grand Rapids, MI: Faith Alive Christian Resources, 2007); Denis Alexander, *Creation or Evolution: Do We Have to Choose?* (Oxford, UK: Monarch Books, 2008); Denis O. Lamoureux, *Evolutionary Creation: A Christian Approach to Evolution* (Eugene, OR: Wipf and Stock, 2008), among many others.
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