Did Morality First Evolve in *Homo erectus*?

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Abstract

With findings from cognitive science, neuroscience, information science, and paleoanthropology, an anthropologist and astronomer-priest team take a new look at the nature of morality, and suggest parameters that are often very different from the philosophical and theological literatures. They see morality as a biologically-based arbitration mechanism that works along a timeline with a valence of good to bad. It is rational, purposeful, social, and affected by emotion but not dominated by it. The authors examine the age and sex structure, family roles, environment, cognition, and lifeway of *Homo erectus*, an early hominin who arose 1.9 million years ago, and propose that he had a rudimentary moral system that his biology and culture enabled – but only after he learned to control fire. Hearths gave rise to an intense, social, emotional,

experiential context where belief systems could be learned by youth before they achieved adult cognition.

Keywords

cognitive science; culture; evolution; *Homo erectus*; hominin; Left Hemisphere Interpreter (LHI); neuroscience; paleoanthropology; scavenging; sociability (sociality)

Evolutionary origins of human morality and religious capacity

We are an anthropologist/astronomer-priest team with an interest in the origins of religion, which overlap substantially with those of morality. The combination of our perspectives has given us a new approach to the foundations of science, religion, and art, (and possibly cuisine and sport) – what we call the "Advanced Domains of Thought." These human abilities rely on an intelligence that is able to combine and recombine mental constructs, including the transposition of entire mental structures from one domain to another, in order to create new cultural products, in an exercise we call "matrix thinking" (*cf*. Rappaport & Corbally, 2015). Our interest in the origins of morality arose because it is fundamental to the development of religion in human beings, and because paleoanthropological findings suggest that an early member of our genus may have developed a biology and a lifeway that could support moral systems, as much as a million years ago – perhaps more.

We came to see morality differently from its many portrayals in the philosophical and theological literatures. When we viewed it as a phenotypic, biologically-based characteristic of all humans, we saw that morality was a capacity for decision-making that is rational, purposeful, social, and affected by emotion but not dominated by it. If there is any emotion that emerges in the application of a human moral system, it appears to us that the principal emotions are initially sadness and regret, which are followed by resolution, and hope and faith in the future. We did not see empathy as a necessary feature of morality, although it is one that frequently attends it – often to good effect, and sometimes not. We did not understand empathy as central to the evolution of moral capacity, although many philosophers and anthropologists do (*cf*. De Waal, 2009). We did not see morality as a complicated form of altruism (whichever of its many definitions one chooses), as many have. Instead, we saw a moral system cognitively as an arbitration mechanism that works along a timeline with a valence from "good" to "bad." That was its underlying cognitive nature in all cultures and all times, and it required a neurological foundation to support it, which came before the cultural product of integrated norms and rules.

We present a model for the origins of a rudimentary morality in *Homo erectus*, an earlier member of our genus who arose around 1.9 million years ago (mya). We review the species' age structure, technology, food-getting activities, and environment. We propose that these are all features that, as described in the paleoanthropological literature, would together suggest hominins with brains that could support a capacity like morality. However, we believe it is most likely that morality became a working, neurologically-based system after *Homo erectus* learned to control fire. That skill laid the foundation for a completely different lifeway that centered around the human hearth, or hearths, because bands of *Homo erectus* were 100-110 individuals, so there would have been more than one.

Importance of fire

Until recently there has been little evidence for the control of fire because there are no charcoal pits until around 350,000 years ago. Coolidge and Wynn (2009, p. 115) point out that fire does not require structured hearths, and they cite a burnt animal bone dating back to 1.4 million years ago in Kenya. On a variety of evidence, they conclude the following: "We think it likely that *Homo erectus* used fire. They need not have been able to make fire, just capture it from natural burns…" It is important to remember that *Homo erectus* was not the first member of the genus *Homo*, but that he followed *Homo habilis*, who emerged at around 2.5 mya and was likely the first stone tool maker. However, the ecological niche of *Homo habilis* was not ideal for the development of a capacity as complex as morality – the focus of our interest here. The species, according to Coolidge and Wynn (2009, p. 129), was still living in the trees much of the time. *Homo habilis* was "a small bipedal ape that almost certainly spent considerable time in the trees, including sleeping" (Coolidge & Wynn, 2009, p. 207). These authors contend that meat acquired through scavenging was a dietary shift that removed selection against large brains, and that this change in diet led to a significant grade shift in hominin evolution (Coolidge & Wynn, 2009, p. 207). The new lifeway required a commitment to living on the ground, and this change introduced adaptations that resulted in the evolution of *Homo erectus* by 1.9 mya.

It was *Homo erectus* who made one of the most important changes for the development of the first moral systems. *Homo erectus* took a major "cognitive leap" by leaving behind the ape pattern of nesting in trees, to sleep soundly on the ground and thereby practice important daily activities by priming in specific sleep segments (Coolidge, Wynn, Overmann & Hicks, 2015, pp. 182–186).

Full, upright bipedalism, aggressive scavenging of meat to feed a larger brain, and the control of fire came together in *Homo erectus*, we believe, around a million years ago to create the circumstances where a rudimentary form of morality could develop. This was a time when *Homo erectus* also began to migrate out of Africa and populate Eurasia. The timing of the emergence of the control of fire has become a critically important area of research. Until recently, it was thought that *Homo erectus* probably learned to control fire from natural burns around a million mya.

New evidence has emerged that supports this contention, but also poses another question: Did the control of fire earlier develop, still? The evidence comes from work at Wonderwerk Cave in South Africa, which demonstrates control of fire and suggests hominin cooking at one million mya (Berna *et al*., 2012). This evidence updates human hearths at 350,000 years ago by 650,000 years – no small achievement.

Wonderwerk Cave shows evidence of habitation for almost two million years. While there are no skeletal remains, the team of archaeologists believes that the hominin who made the fire was *Homo erectus*. To the theoretical discussion of the role of fire, we add our consideration of the growing dominance of more advanced and efficient C_4 (as opposed to C_3) grasses (*cf*. Ripley *et al*., 2010; Edwards *et al*., 2010). C_4 carbon fixation uses the first results of carbon fixation (a four-carbon molecule). It is a further development of a process using three-carbon chemical results, and C_4 probably evolved more recently. Where it is found, it often tends to dominate the ecology. The higher flammability of C_4 grasses, we believe, had a role in both the biological and cultural evolution of the human lineage, and therefore the emergence of morality and religious capacity. If the species *Homo erectus* was reliant on natural burns as a source of fire, then it was especially fortuitous that the often more flammable C_4 grasses predominated in parts of the African savannah environment during the species' tenure.

Scholars have analyzed the function of fire in human evolution, for example Burton (2009) and Wrangham (2009), but none has addressed its importance in the emergence of a combined biological capacity and a cultural product like morality. We feel that it is probable that, with the species of *Homo erectus*, the switch from biological evolution to cultural evolution on the human lineage sped up – although by no means did biological evolution ever stop (Cochran & Harpending, 2009). By the time we see *Homo heidelbergensis* 600,000 ya (thought by many to be "early *Homo sapiens*"), cultural evolution had become dominant, and a major, reciprocal influence on biological evolution because it changed the environment to which species adapted.

Feedback in cognitive evolution

We have written elsewhere of "an essential feedback loop in cognitive evolution," which we understand as a natural mechanism that occurs when hominins began to create "external storage devices" (Rappaport & Corbally, 2016). When members of the genus Homo started to store information outside the brain, for manipulation later, the storage devices (incisings on clam shells and ochres, for example) became part of the environment – indeed, a part to which the species further adapted.

We would add that when species on the human lineage began to construct very complex cultural systems, such as those that might reflect morality and religious belief, those structures could have also constituted a significant part of the environment to which natural selection responded. Colagè (2015) has recently suggested one mechanism by which this feedback occurs. Both the external storage of information and complex cultural structures such as morality would affect the selection of brain capacities that could take advantage of these new inventions. Based on ethnographic evidence of existing hunter gatherers, we speculate on social activities that likely occurred around a communal fire or fires for 100–110 *Homo erectus* individuals, and which gave rise to a culturally constructed set of norms and rules called "morality." The biological components come first, followed by the cultural, which can change the biology of a species through what has been termed, "cultural neural reuse" (Colagè, 2015), and perhaps other, as yet unidentified mechanisms. There is a biological foundation for moral decision making, upon which a cultural system is built. No matter which hominin species first developed morality, the brain had to be ready biologically to support it when it was invented.

Some of a foundation for morality already existed in primates before *Homo erectus* evolved, for example, intense sociability in troops that dated to the earliest primates, and a capacity for deep emotions and heightened intelligence, which was already expanding before the split with the chimpanzees (Harris, 2015). Genomic anthropologist Eugene Harris puts our relationship with an ancestral ape that gave rise to the chimpanzee and human lineages, this way:

> …it is possible that those regions of our genome in which we are more similar to one or another of the great apes might be impor-

> tant functional regions of the genome that provide the DNA blueprints for certain anatomical or behavioral features. We also may be unspecialized, unlike any of these other apes but more like the primitive ape from which all living great apes evolved. Our genome contains the seeds of many unique features, including many of our well-known adaptations like erect posture and bipedal locomotion, our complex language abilities, and our massive brains and greatly augmented cognitive abilities (Harris, 2015, pp. 33–34).

We view morality as a new feature of the human lineage, but one that emerged from a very large genome and a biology endowed with a high degree of plasticity. As far as we know, no other species has developed a system of arbitrating moral good vs. moral bad along a timeline, with the result that a resolution is achieved that allows the group to go on, with hope for the future.

Like other phenotypic human characteristics, we believe that both religion and morality are evolved, biologically-based, cognitive, intellectual, and emotional capacities of our species, and our species alone. We ground our work in the latest scientific findings from genomics, paleobiology, "stones and bones" archaeology, the new cognitive archaeology, and especially cognitive science and neuroscience, which are providing our first maps of the brain activities involved in moral decision making and religious expression (Van Slyke, 2011; Gazzaniga, Ivry & Mangun, 2014). We believe religion and morality are key indicators of what makes humans distinctive, even unique, as a species. Our living primate relatives do not have moral capacity, and we are supported in this by many philosophers (e.g., Kitcher, 2009; Korsgaard, 2009). The higher apes are intensely social and we can see our behavior in field studies of primates, but moral reasoning is beyond their reach. Basic "altruism" does not equal morality, using our definition.

First moral systems

We hypothesize that the first, rudimentary moral systems appeared about a million years ago (possibly earlier) in *Homo erectus*, a successful member of our own genus who lasted over 1.8 million years. Our own species, *Homo sapiens*, has existed for only 200,000 years. We base our model partly on work by Colagè (2015), who reports that "cultural neural reuse" changes tissue through cultural learning (especially, reflective reading) and helps to produce moral and religious "transcendence." We believe that cultural neural reuse may have operated fairly frequently in the evolution of morality, and that it helped to hard-wire moral capacity to the extent that it now exists in humans, because we are still evolving (Cochran & Harpending, 2009). The implications of their findings for modern anthropology suggest there is no neat separation between "biological adaptation" and "cultural adaptation." Beginning at least with *Homo erectus*, they operated in tandem, each affecting the other.

Human plasticity and the genetic basis for culture

Human plasticity, both biological and cultural, is essential in understanding the distinctiveness of the human lineage and the features that evolved only in our species (Varki & Altheide, 2005, p. 1747). We believe that the high degree of plasticity on the hominin evolutionary line sets the stage for the emergence of the first moral systems in *Homo erectus*. Moral systems are firm and precise, but flexible in their application. They provide a framework into which the vicissitudes of life can never perfectly fit, so they can change as human capacities evolve and as cultures change. Moral rules are part of culture, and the capacity for culture has a biologically inherited basis that is very ancient – at least to a point in time before the split between humans and chimpanzees, around six or seven million years ago. Both chimpanzee species (*Pan troglodytes* and *Pan paniscus*) and all later hominins (*Homo sapiens sapiens*, *Homo sapiens idaltu*, *Homo neanderthalensis*, and the *Denisovans*) undoubtedly had some capacity for culture, irrespective of degree. Still, humans are the only living species that has relied on culture pervasively. It is likely that we will eventually identify the genomic segments that are responsible for our and our near relatives' capacity for culture. At the present, research in genomics is focusing upon those genome segments that make modern humans unique. These segments are found particularly in the HARs (Human Accelerated Regions) of the genome, and they are broadly dispersed on our 46 chromosomes. Human Lineage Specific (HLS) genes are scattered throughout our genome – not in just a few areas – so our uniqueness is scattered throughout our genome. It is not localized to a few specific regions.

Human plasticity and a capacity for culture are important when we model how moral capacity evolved. Philosopher Philip Kitcher (2009, pp. 120–139) finally uses the term "stuck" in his critique of Veneer Theory – that morality is a thin veneer over an instinct-driven biology. He complains that among chimpanzees,

> … psychological altruism… is always breaking down… and has to be repaired [with] long bouts of grooming… These animals could use their time and energy much more efficiently and profitably than they do, were they to have some device for extending and reinforcing their dispositions to psychological altruism… [It] would provide them a smoother, more functional society… their group size could grow. Because those forms of psychological altruism are so limited they are socially stuck, unable to achieve large societies or more extensive cooperation. (Kitcher, 2009, p. 135)

Morality's common origin

Morality, as a universal but individually variable feature of both human biology and culture, almost certainly had a common birth for all humanity. This helps to explain why all moral systems somehow seem the same, even if we cannot pinpoint exactly why, and even when certain features of this moral system or that one seem horrible and inhumane. All human moral systems seem to incorporate the following features: a mental step both back and up; an arbitration mechanism that operates along a timeline; an evaluation using a valence from good to bad; a regretfully dispassionate reasoning; a tentativeness in a mental balancing act; a sad rejection of "wantonness"; sometimes, an empathy with someone receiving moral judgment; and the experience of a burden. The result of the application of all moral systems is resolution, so that the group can continue with hope and faith in the future.

Neuroscientist-turned-philosopher Sam Harris rejects cultural relativism and defends a universal, scientific, and common sense approach to the evaluation of moral systems (2010; 2011). This seems intuitively right based on our knowledge of *Homo erectus* and what must have been the species' need for a practical approach to right and wrong. If morality is as old as *Homo erectus*, then Harris' "universal conception of morality" makes solid sense, because it arose in response to a group requirement to confront the conflicts of different norms and values, whose resolution allowed the group to "go on" with hope and in good spirit.

A model of "The Human Hearth" and its role in creating the first, rudimentary moral systems suggests how morality may have arisen in *Homo erectus*. The original African environment is known – woody but not forested, with open grasslands that could easily catch fire. *Homo erectus* was a fully bipedal species who was already far more advanced than any living chimpanzee, so comparisons to living primates remain limited. The species had a full stride, and was the first hominin to leave Africa and populate other large land masses (Templeton 2005; Stringer 2012). *Homo erectus* walked fully upright for a million years (perhaps less, with new archaeological findings) before learning to control fire, when, we propose, "The Human Hearth" arose. Moral systems began to emerge in response to specific features of the new environment that a communal fire encouraged. Even today, the hearth remains "home" to humans in every sense of the word.

Psychologist Coolidge and archaeologist Wynn (2009) emphasize that fire use does not require structured hearths. They write,

> … it is likely that *Homo erectus* used fire. They need not have been able to make fire, just capture it from natural burns… The use of fire has several benefits. One is warmth… Another is discouraging predators… If used in cooking, fire can break down the chemical defenses of many plant foods… and aid the digestion of meat [which] *Homo erectus* needed to feed its enormous brain… (Coolidge & Wynn, 2009, p. 115)

Homo erectus was the first completely terrestrial species in the genus *Homo*, both sleeping and waking. The *selection pressure against* a lengthening Stage 4 (slow wave) and REM sleep, and, an extended sleep period of eight or nine hours, was *reduced* for *Homo erectus* (Coolidge & Wynn, 2009, p. 148, emphasis added). Said another way, Stage 4 and REM sleep were allowed to expand because the hominin could afford to remain asleep for long periods and still not jeopardize the band's safety or impair their potential to find enough food. Until *Homo erectus* emerged with an ability to range widely and obtain enough high-quality food, a large brain would have placed an untenable energy and protein burden on any creature, so it could not and did not develop.

Table 1 summarizes cranial and morphological data for the australopithecines, *Homo erectus*, and *Homo sapiens* (us). The large jump in cranial size from the australopithecines to *Homo erectus* is the significant change that is attributed to full-time terrestrial life maintained by and for consuming meat. Other features were just as important and would become even more pronounced in species of the genus *Homo*. *Homo erectus* had smaller teeth, a smaller face, and a body that was more gracile, with longer legs, shorter arms, and a slimmer body able to cool itself more easily on long treks.

Table 1.* Emergence of Characteristics That Support Moral Systems Development in the Human Lineage.

	Cranial capacity	**Neo-cortex ratio****	**Gait, Build, Posture**	**Sexual Dimorphism**
Australo-pithecines	350 - 600cc	3.1 - 3.2	Bipedal, but ape-like gait	Distinct sex differences
Homo erectus	1000 - 1100cc	3.7 - 3.8	Fully bipedal gracile	Reduced
Homo sapiens	1300 - 1400cc	3.9 - 4.0	Fully bipedal more gracile	Further reduced

* Figures are estimates from data in Aiello & Dunbar (1993), and Barnard (2008).
** Ratio of the neo-cortex to the rest of the brain.

Species characteristics enabling moral systems to develop

The leap in brain size from the australopithecines with 350-600cc, to *Homo erectus* with around 1000cc, is consistent with a need for sheer computing power to make moral decisions. The portion of the brain involved in complex decision-making and long-term planning – the "executive functions" – leaped, with an australopithecine neocortex ratio of about 3.1 (*A. afarensis*, *A. africanus*) compared to approximately 3.7 for *Homo erectus* (Aiello & Dunbar, 1993, p. 188). These changes, along with the establishment of a mental timeline, are consistent with a need to calculate, model, project, and weigh the potential consequences of moral decisions. We propose that moral systems are on a higher level of complexity than social systems, which explains why efforts to derive human morality from living primate social behavior always appear to fall short (Kitcher, 2009; Korsgaard, 2009).

The group size of *Homo erectus* bands averaged 100-110 individuals (Aiello & Dunbar 1993, p. 188). The lifespan of *Homo erectus* was about 45 years at death, although some estimates are as high as the early 60s (Carey, 2003; Hawkes, 2003; 2004). The territory of a band of *Homo erectus* varied with the local environment, but may have grown to an average of ten times larger than the home territory for the australopithecines (Coolidge & Wynn, 2009, p. 117).

Density of population and density of social interaction may have been very important factors in the emergence of moral systems. For problems that rose to a certain level of importance, there were ample opinions on "the right thing to do." Furthermore, *Homo erectus* probably had an important medium to weigh decisions – rudimentary language when he emerged at 1.9 mya, and full grammatical language by 1 mya, when time spent grooming likely rose to a level of 30 percent. Dunbar (1996, p. 114) proposes this level as the point when grooming should decline and language arise to cement social relationships, and that this level occurred during the time of *Homo erectus*. The hyoid bone in the throat is found beginning about 2.5 million years ago, close to the time that the genus Homo originated. It indicates a change in vocal structure and mechanism. At 1 mya, *Homo erectus* very likely relied on language. Speech and better sleep on the ground may well have helped the species create new ideas, and arbitrate them in a moral context.

Homo erectus was larger than the earlier australopithecines and sexual dimorphism was much reduced. Females were larger and may have required almost as much energy as males; the diet of *Homo erectus* had more protein, probably due to "aggressive scavenging" (Coolidge & Wynn, 2009, p. 116–118). The need for energy by larger, pregnant, and lactating females may have been partially met through food-sharing by the mother's mother. Opie and Power (2008, p. 176) used time data on the eruption of the third molar for chimpanzees and human forager females to estimate that the age at last pregnancy was 33. If females lived to 45 years, that would give them *12 post-reproductive years*.

Menopause is universal in humans (Varki & Altheide, 2005, pp. 1747–1748), but it does not usually arise in a search for morality's origins. Long postmenopausal life segments differentiate humans from other primates (Hawkes *et al*., 1998). One proposed explanation for menopause (the "Grandmother Hypothesis") is that post-menopausal females provisioned their own daughters and thereby improved the likelihood that their genes would survive. Our view is that females not only contributed food and skills, but ideas. Longevity – another phenotypic human trait noted by biologists (Varki & Altheide, 2005, p. 1747) – has been closely linked to the idea that menopause is an adaptation (Williams, 1957). Indeed, historical research confirms the length of a female's life after menopause is reflected in the reproductive success of her offspring and her grandchildren's survival (Lahdenperä *et al.*, 2004).

All of these characteristics lead to tantalizing suggestions about the role of the elder members of *Homo erectus* bands, male and female, in the emergence of moral systems. Did morality emerge partly because there were enough older members to share lifetimes of experience and accumulated wisdom, which had not yet developed in the young? Did these elders arbitrate decisions rather than acting upon them with an impetuous first hunch? Did they allow the young to make mistakes only to create examples of the "wrong approach"? It is tempting to envision a single "wise old man" or "wise old woman," but it is more likely that moral systems required a debate among several of the elderly, which were available in longer-lived bands of

Homo erectus. A key feature of morality has always been wisdom, which usually does not emerge until well into adulthood, if at all. Longevity is a key factor in any model of the first moral systems developing in *Homo erectus*.

This brief overview of *Homo erectus* – irrespective of his use of fire – suggests that the species could well have been in an evolutionary position to have structured cultural systems that codify concepts of right and wrong, encourage arbitration of outcomes for all band members, and most important, step back from indiscriminant action – from "wantonness," which is sometimes used by philosophers to distinguish humans from other animals.

A model for the evolution of morality

Modern cognitive science and neuroscience give us features needed in moral thinking, in particular: (1) the concept of a mental timeline, (2) an explanation-maker that would generalize from lifetimes of experience, and (3) the conception of a valence from good to bad for the species. Once these features appeared, Colagè's mechanism of "cultural neural reuse" would then favor aspects of the species' biology that were useful in moral thinking, and morality would be captured by the brain over many thousands of years. It would become an inherited capacity, although one not always used, like reading is not always used (Colagè 2015).

Table 2 summarizes the concepts needed to complete our model of morality in *Homo erectus*. They come from a variety of different literatures – archaeology, neuroscience, philosophy, and ethnology. The archaeology literature demonstrates that *Homo erectus* clearly was able to operate on a timeline because he used it in the multi-stage construction of stone tools. Given this timeline, it is probable that *Homo erectus* had already incorporated an emergent Left-Hemisphere Interpreter (LHI) to constantly search for explanations – a neurological concept that has emerged out of decades of neuroscience research (Gazzaniga, 1999; 2006). A valence of good to bad is embedded in the biology of *Homo erectus*, who, as a species that must have lived often at the edge of existence, favored conditions, effects, and states that fostered well-being, and life, itself, within a supportive social context. The origin and emergence of a valence from good to bad will be the focus of a paper that is currently in preparation. Our formulation will focus additionally on the arbitration mechanism that allowed humans to select among explanations – since the LHI is not necessarily science-based. It simply produces explanations.

Table 2. Factors Essential to a Paleolithic Model of Moral Decision-Making.

Required	Relevant Context	Theoretical Basis
Timeline	Construction of multi-stage stone tools	Archaeology Planning Imagining in 3 dimensions Multi-step construction Use of hand axes
Explanation-maker	An emergent Left Hemisphere Interpreter (LHI)	Neuroscience Running interpreter that constantly makes up explanations (Gazzaniga, 1999, 2006)
A valence from good to bad	Lifestyle of *Homo erectus*, focused on The Human Hearth and the circle of light	Philosophy and Ethnology Definition of moral capacity and how it is expressed in various groups described in the ethnographic literature

The human hearth

The lifeway of *Homo erectus* changed once the species controlled fire, providing a matrix of intense social and emotional life. The species was aided by better sleep that provided an opportunity for social rehearsal, and new and different capacities came under the pressure of natural selection. Among these was a rudimentary moral system.

We propose that The Human Hearth provided an opening for a new system of settling disputes, creating cohesion, resolving tragedies, and answering questions about existence, so that the group could go on with hope and faith in a future. Elders may have taken the lead in laying out the pros and cons of moral decision-making. By the time of *Homo erectus*, there would be an elder population of at least several individuals, probably of both sexes. Women were physically larger (compared to australopithecines) and they had more roles in sustaining the group, especially their daughters and grandchildren, so their voices must have been heard, too.

Sanctioning and teaching the young took place within the group context of The Human Hearth, and the lengthening of childhood began, along with an intensification of both individual and social parenting. The circle of light created by a hearth creates a sharp distinction between wild and tame, them and us, the un-touched and the culturally crafted, or as anthropologist Lévi-Strauss (1975) termed it, "the raw and the cooked". Indeed, the striking difference between being "in the light of the Hearth" and outside it, may well have been one of the early dualities that Lévi-Strauss describes so convincingly in *Structural Anthropology* (1974). There is no question about a boundary of safety. To be inside the light is good and to be outside it means danger. The circle of light created by The Human Hearth could well have been used to concretize and reify the difference between "moral good" and "moral bad."

The Human Hearth may have been one of the origins of the cognitive lag in human children. Researchers propose that prolonged prefrontal immaturity is, on balance, advantageous and that the positive consequences of this developmental trajectory outweigh the negative. They argue that cognitive control impedes convention learning and delayed prefrontal maturation is a necessary adaptation for human social learning (Thompson-Schill, Ramscar, & Chrysikou, 2009, p. 259).

We agree that it would have been useful for immature *Homo erectus* to be initially unable to think for themselves within a lifeway set around The Human Hearth, where fables of others (human and supernatural) were recounted, where lessons for correct behavior were taught by example, and where religious beliefs in spirits first took hold. In this way, a system of good and bad was passed on pre-formed to younger members of the band. An evolving LHI would derive explanations, but then a polarity from good to bad was applied to evaluate explanations, in what would become a moral context. By the time adulthood was reached, the code of good and bad, correct and erroneous, acceptable and unacceptable, was already set within the context of The Human Hearth.

Together, stories, tragedies, disagreements, and dispute resolution all came together to create a moral code as part of the culture – not just a habit or fad – but a full structure that covered most types of hominin behavior. The transition in adaptive strategy would, from the point when The Hearth emerged, be predominately cultural, with support from a biology whose plasticity continued to confer advantages by allowing new capacities to develop, like reading did much, much later. Individual band members would step back and look out from a higher perspective, and understand the instance-at-hand as one in a larger category of moral questions.

The acceptable explanations need not conform to science, only to the cultural knowledge base of good and bad, believed and not believed, which the social interaction of the group over thousands of years had devised and tested. There would be revolts, especially among the young, as there are now, when a new way of thinking was introduced. It would be challenged, especially by the elderly, but eventually, new ideas would take hold.

Note

This paper is based on an April 25, 2016, presentation to the Polish Academy of Arts and Sciences, and a follow-up discussion at De Revolutionibus Books & Café. A more detailed exploration of the model of The Human Hearth and the origin of the first moral systems in *Homo erectus* appears in *Zygon; Journal of Religion and Science*, *51(4)*, pp. 835–866, December 2016.

References

Aiello, Leslie C., Dunbar, R.I.M., 1993. Neocortex size, group size, & the evolution of language. *Current Anthropology*, *34(2)*, pp. 184–193.

Barnard, A., 2008. The co-evolution of language & kinship. In: N.J. Allen, H. Callan, R. Dunbar, W. James, (eds.), *Early human kinship; From sex to social reproduction.* Malden, MA: Blackwell Publishing, pp. 232–243.

Berna, F., Goldberg, P., Kolska Horwitz, L., Brink, J., Holt, S., Bamford, M., Chazan, M., 2012. Microstratigraphic evidence of in situ

fire in the Acheulean Strata of Wonderwerk Cave, Northern Cape province, South Africa. *Proceedings of the National Academy of Sciences*, *109(20)*, pp. E1215–E1220.
Burton, F.D., 2009. *Fire: The spark that ignited human evolution*. Albuquerque: University of New Mexico Press.
Carey, J.R., 2003. *Longevity: The biology & demography of life span*. Princeton: Princeton University Press. Table 9.3 Evolved Life Span of Ancestral Hominids & Modern Humans. p. 215.
Cochran, G., Harpending, H., 2009. *The 10,000 year explosion: How civilization accelerated human evolution*. New York: Basic Books.
Colagè, I., 2015. The human being shaping & transcending itself: Written language, brain, & culture. *Zygon. Journal of Religion and Science*, *50(4)*, pp. 1002–1021.
Coolidge, F.L., Wynn, Th., 2009. *The rise of Homo sapiens: The evolution of modern thinking*. Chichester, UK: Wiley-Blackwell.
Coolidge, F.L., Wynn, Th., Overmann, K.A., Hicks, J.M., 2015. Cognitive archaeology and the cognitive sciences. In: E. Bruner, (ed.), *Human paleoneurology*. New York: Springer.
De Waal, F. 2009. *Primates and philosophers: How morality evolved*. Princeton: Princeton University Press.
Dunbar, R., 1996. *Grooming, gossip, and the evolution of language*. London: Faber & Faber. Fig. 4, Grooming Time Predicted for Individual Fossil Hominid Populations Plotted Against Time.
Edwards, E.J., Osborne, C.P., Strömberg, C.A.E., Smith, S.A. and C4 Grasses Consortium, 2010. The origins of C4 Grasslands: Integrating evolutionary and ecosystem science. *Science*, *238*, pp. 587–591.
Gazzaniga, M.S., 1999. *The interpreter within: The glue of conscious experience*. Dana Foundation web site, April 1. http://www.dana.org/Cerebrum/Default.aspx?id=39343#sthash.I7zCiFeL.dpuf.
Gazzaniga, M.S., 2006. *The ethical brain: The science of our moral dilemmas*. New York: Harper.
Gazzaniga, M.S., Ivry, R.B., Mangun, G.R., 2014. *Cognitive neuroscience: The biology of the mind*. 4th ed. New York: W.W. Norton & Co.

Harris, E.E., 2015. *Ancestors in our genome: The new science of human evolution*. Oxford: Oxford University Press.

Harris, S., 2010. HuffPost Books, The Blog. *Moral Confusion in the Name of 'Science.* Original: 05/29/2010 05:12 am ET. Updated: May 25, 2011. Based on a 2010 TED conference presentation.

Harris, S., 2011. *The moral landscape: How science can determine human values*. New York: Free Press.

Hawkes, K., 2003. Grandmothers & the evolution of human longevity. *American Journal of Human Biology*, *15(3)*, pp. 380–400. doi:10.1002/ajhb.10156. https://www.ncbi.nlm.nih.gov/pubmed/12704714

Hawkes, K., 2004. Human longevity: The grandmother effect. *Nature*, *428(6979)*, pp. 128–129.

Kitcher, Ph., 2009. Ethics & evolution: How to Get here from there. In: F. De Waal, *Primates and philosophers: How morality evolved*. Princeton: Princeton University Press, pp. 120–139.

Korsgaard, Ch., 2009. Morality & the distinctiveness of human action. In: F. De Waal, *Primates and philosophers: How morality evolved*. Princeton: Princeton University Press, pp. 98–119.

Lahdenperä, M., Lummaa, V., Helle, S., Tremblay, M., Russell, A.F., 2004. Fitness benefits of prolonged postreproductive lifespan in women. *Nature*, *428(6979)*, pp. 178–181. doi:10.1038/nature02367. https://www.ncbi.nlm.nih.gov/pubmed/15014499.

Lévi-Strauss, C., 1974. *Structural anthropology*. New York: Basic Books.

Lévi-Strauss, C., 1975. *The raw and the cooked*. New York: Harper & Row.

Opie, K., Power, C., 2008. Grandmothering and female coalitions: A basis for matrilineal priority? In: N.J. Allen, H. Callan, R. Dunbar, W. James, (eds.), *Early human kinship: From sex to social reproduction.* Malden, MA: Blackwell Publishing, pp. 168–186.

Rappaport, M.B., Corbally, Ch., 2015. Matrix thinking: An adaptation at the foundation of human science, religion, and art. *Zygon. Journal of Religion and Science*, *50(1)*, March, pp. 84–112.

Rappaport, M.B., Corbally, Ch., 2016. The human hearth and the dawn of morality. *Zygon. Journal of Religion and Science*, *51(4)*, December.

Ripley, B., Donald, G., Osborne, C.P., Abraham, T., Martin, T., 2010. Experimental investigation of fire ecology in the C3 and C4 subspecies of *Alloteropsis semialata*. *Journal of Ecology*, *98(5)*, pp. 1196–1203.

Stringer, Ch., 2012. *Lone survivors: How we came to be the only humans on earth*. New York: Times Books. Especially, Ch. 5, "Behaving in a Modern Way: Mind Reading & Symbols."

Templeton, A.R., 2005. Haplotype trees and modern human origins. *Yearbook of Physical Anthropology*, *48*, pp. 33–59.

Thompson-Schill, S.L., Ramscar, M., Chrysikou, E.G., 2009. Cognition without control: When a little frontal lobe goes a long way. *Current Directions in Psychological Science*, *18(5)*, pp. 259–263.

Van Slyke, J.A., 2011. *The cognitive science of religion*. Burlington, VT: Ashgate Publishing.

Varki, A., Altheide, T.K., 2005. Comparing the human and chimpanzee genomes: Searching for needles in a haystack. *Genome Research*, *15*, pp. 1746–1758.

Williams, G.C., 1957. Pleiotropy, natural selection, and the evolution of senescence. *Evolution*, *11(4)*, pp. 398–411. doi:10.2307/2406060. https://www.jstor.org/stable/2406060.

Wrangham, R., 2010. *Catching fire: How cooking made us human*. New York: Basic Books.