THE HUMAN HEARTH AND THE DAWN OF MORALITY

by Margaret Boone Rappaport and Christopher Corbally

Abstract. Stunned by the implications of Colagè's analysis of the cultural activation of the brain's Visual Word Form Area and the potential role of cultural neural reuse in the evolution of biology and culture, the authors build on his work in proposing a context for the first rudimentary hominin moral systems. They cross-reference six domains: neuroscience on sleep, creativity, plasticity, and the Left Hemisphere Interpreter; palaeobiology; cognitive science; philosophy; traditional archaeology; and cognitive archaeology's theories on sleep changes in *Homo erectus* and consequences for later humans. The authors hypothesize that the human genome, when analyzed with findings from neuroscience and cognitive science, will confirm the evolutionary timing of an internal running monologue and other neural components that constitute moral decision making. The authors rely on practical modern philosophers to identify continuities with earlier primates, and one major discontinuity—some bright white moral line that may have been crossed more than once during the long and successful tenure of *Homo erectus* on Earth.

Keywords: Ivan Colagè; cognitive science; cultural neural reuse; evolution; hominin; *Homo erectus*; morality; natural selection; neuroscience; suprasocial; Wallace's Conundrum

> If there were witchcraft, I'd make two wishes,
> A winding road that beckons me to roam,
> And then I'd wish for a blazing campfire
> To welcome me when I'm returning home.
>
> Camp Song

POROUS BOUNDARY BETWEEN BIOLOGY AND CULTURE

In Ivan Colagè's recent article (2015) in *Zygon: Journal of Religion and Science*, a philosopher takes on a question of great importance to theology

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with research results from neuroscience. He finds evidence for human transcendence in both the unique biology and mentality of the current remaining species of the genus *Homo*. In doing this, Colagè finds himself in the good company of neuroscientists-turned-philosophers like Michael Gazzaniga (2006), Sam Harris (2010, 2011), and others who seem to be on a modern philosophical upswing after a lull in the literature on evolutionary morality beginning around 2007, which we found odd. It seemed to us that philosophers needed more to talk about than living primate studies, and now they have indeed found it in the findings of neuroscience and, we would add, cognitive science.[1]

Colagè easily incorporates neuroscience into philosophical discussion. He presents evidence that living humans can overcome the vagaries of their desires and first inclinations, and become something more through "transcendence," an important mechanism in achieving a moral human. He writes "that human beings transcend themselves *both* at the biological and at the cultural level" (2015, 1002), and this emerges from fascinating details on the neuroscience of literacy. Because the basis for transcendence is, in part, found in culture acting on biology through reading, the evidence he presents is crucially important in any formulation of human moral thinking, and so his work is interesting and noteworthy from that perspective alone.

Colagè does not take on the issue of how our species came to have a capacity for transcendence, or how moral systems evolved biologically and matured culturally from lines of hominins who must *not* have had such a capacity. Somewhere along the lengthy lines of mammals, early monkeys, later apes, and hominins, either on our line or another line interbreeding with it, something happened. A line was crossed, and we have written about this with respect to religious thinking, which is coterminous with much, but not all, of morality (Corbally and Rappaport 2013). Here, with inspiration from Colagè's presentation, we suggest a theoretical model for how the first moral systems may have emerged and in what environment. We believe that the mechanism of cultural neural reuse, which Colagè relies upon in his discussion of literacy, must have been involved at yet other junctures in the evolution of moral capacity on the hominin line.

We shall return to the emergence of morality after first examining some of the broader implications of Colagè's use of neuroscience for anthropology, and why it is important for our model of a context for the first moral systems. Colagè has, perhaps inadvertently, found a fruitful approach to a very old question in anthropology: When and how did the human line transition from reliance upon biological adaptation (mutations, natural selection, and evolution) to an existence whose adaptive strategy is mostly cultural, and therefore taught, learned, and embodied in the consciousness of groups of people? Colagè's work illustrates that culture changes biology—a fact long known by anthropologists, if haphazardly proved.

Our own understanding of the relationship between biology and culture changes after delving deeply into Colagè's results. He shows that culture changes biology, so the question about a transition from biology to culture changes. There is no neat separation between the two adaptive strategies.

It has been a foundation of modern anthropology that humans now rely on culture, while their evolutionary past involved millions of years when biological evolution shaped their primary responses to, and softened the interface with, a variety of changing environments. The human lineage was typically seen as "switching over" from one main type of adaptive strategy to another, from biology to culture, and ours is the only species to "switch over" quite so far, indeed to the point where we now ask: Does culture *prevent* the operation of natural selection because it cushions humans quite so well from its force? We are fortunate that several related species remain on Earth that bear culture less fully than we do. Their very existence attests to the biological antiquity of a capacity for culture. We shall focus on part of this: A capacity for morality, which we assume has a fundamentally biological basis.

CO-OPTING A CAPACITY ALREADY PRESENT AND TISSUE ALREADY ENGAGED

Chimpanzees and some monkeys have been shown to have a limited cultural repertoire of behaviors that are taught, learned, passed on in isolated groups, and these behaviors have, as far as we know, no basis in biological reflexes or instincts, and probably serve little if any reproductive advantage. They are nonutilitarian, so they catch our attention and we ask, why?—just as we ask why one human group has prescribed cross-cousin marriage, while another group proscribes all types of marriage with first cousins. Recent findings show that some chimpanzees even have a type of fashion or fad, for example, the adornment of the ears with long straight pieces of grass (Main 2014). It is a type of behavior that "catches on," is passed from one chimpanzee to another, and comes to typify the group.

As humans, it is difficult for us *not* to make an intuitive guess that to other chimpanzees the grass ear adornments may be seen as "cool," like a young pool shark striking a pose with an unlit cigarette tucked nonchalantly over one ear. He looks "cool." It is not clear what might be a good strategy for researching the concept of "cool" among chimpanzees, but from an evolutionary viewpoint, we must conclude that the common ancestor to both chimpanzees and humans had some capacity for culture, however limited, because 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 culture, irrespective of degree. We conclude that the capacity for culture has a biologically inherited basis. Indeed, neuroscientists are at the forefront of efforts to probe its roots, but they do not often mention this.

Colagè (2015, 1010–12) takes on the task of linking biology and culture by both horns and succeeds admirably in illuminating one of the biological bases of a primary feature of modern human culture—literacy—and how culture activates it neurologically. Reading is a very recent aspect of culture that could not have been subjected to natural selection until Anatomically Modern Humans (AMH) had been on Earth for about 40,000 years. The lateness of reading is consistent with the fact that it is not quite as "fixed" neurologically as many other capacities like speech and seeing constellations (Corbally and Rappaport 2015). Furthermore, reading does not have a specific, narrow, required time span in childhood for optimal development. One can learn as an adult.

Literacy, Colagè reports, is governed by the Visual Word Form Area (VWFA) in the ventral visual cortex. The VWFA overlaps with tissue identified as FG2, and the left FG2 appears to work along with other language areas of the brain. Another area of tissue, the right FG2, functions with different areas of the brain to discern faces and emotions in the face (far older tasks in terms of evolution, than reading, which emerged only 6,000 years ago). The two tissue areas (left and right FG2) do different things in literate humans, and are integrated into "two apparently distinctive functional systems" (Caspers et al. 2014, 10).

It seems at first that we have a version of Wallace's Conundrum (Varki, Geschwind, and Eichler 2008) because there was no way for natural selection to act upon this differentiation of brain tissue for the purpose of reading until very recently. Reading did not exist. Furthermore, evolution could not have "known" or "planned" for reading because evolution is not, by definition, teleological in any way. Therefore, how did literacy and the left FG2 hook up? Surely some of the answer involves neural connections to other parts of the brain that were already formed to allow verbal language. The tissues of the left FG2 may have already been predisposed to become involved in reading when it emerged. By that time, neural networks for oral speech were already well established over a span of perhaps two million years. Furthermore, there are fundamental similarities between reading and the all-important functions of face- and emotion-recognition, and these lie in the perception of fine lines and small changes in them, the shapes they make, and the importance they hold for the viewer's well-being. Colagè puts it this way:

> [T]he basic information-processing capabilities of this brain region (a) depend on evolutionary processes that, however, concern functions *different* from reading, and (b) are *potentially* useful for reading competence. The ability to process fine visual details and an exalted capability for recognizing face emotional expressions are part and parcel of the evolutionary history of primates, likely linked to food-procurement activities (such as finding edible

> seeds or using tools for fishing ants) and to the primate complex social and communicative lifestyles. (2015, 1010–11)

We would add that recognition of faces and their emotional changes, as moderated, in part, through the right FG2, is a major survival strategy for infants and children who must remain in touch with their caregivers to survive. They cannot provision themselves. As primate social structure became more complex, dependency periods lengthened, and long, intimate relationships were established, based in part on interpreting the mutual dispositions of children and caregivers. In citing theory on the enormous importance of "reading" others through their faces, we also note Dunbar's Social Brain Hypothesis (1998), which proposes that one stimulating influence on the expanding brain was a need to keep track of an increasing number of social relationships. Indeed, a single child, according to "The Grandmother Hypothesis" (O'Connell, Hawkes, and Blurton Jones 1999, 2002; Opie and Power 2008), might necessarily need to read the faces of multiple caregivers.

Other theorists have, either directly or indirectly, implicated a need to read faces in theories of "Deep Social Mind" (Whiten and Erdal 2012); the need for all hominins to develop "a theory of mind" (Whiten 1999); and the requirement of a facility called "mind reading" as an important aspect of "behaving in a modern way" (Stringer 2012). Mind reading is an important, rather widely accepted difference between humans and chimpanzees. Researchers have found that in some ways chimpanzees have a "theory of mind," and in other ways they do not (Call and Tomasello 2008).

Interpreting faces is no small matter and it helped hominins survive, but then reading text was no small matter when it came along, so an efficient split of the functions of the left and right FG2 tissue was apparently initiated, although probably not completely finished because, if the proper reading stimulus is not present, the left FG2 simply goes back to its original function. It is not quite hard-wired, not yet, illustrating that we surely remain at some midpoint in evolution.

The bilateral compartmentalization of the left FG2 tissue is not unusual. Hemispheric specialization in neuroscience we have come to expect, and Colagè carefully connects the left brain to literacy, then to the moral codes that written texts embody, thence to moral self-consciousness. This is how he gets from neural tissue to transcendence. For our part, we have come to think of transcendence as "suprasocial"—in part social, but much more. It is a facility and capacity derived on a line of intensely social and emotional animals, but at a different level, because transcendence is a feature of moral systems requiring a mental step both back, and up. Yet, an important question remains: What does "much more" mean when we focus upon the evolution of hominins? To answer this, it will be helpful to model the transition to morality in its first context, by a species that probably had a rudimentary moral system. At the conclusion, we offer a tentative definition for the term "suprasocial" and why it is so important.

CULTURE CHANGES THE BODY

What we find stunning in Colagè's work is that the left FG2 has been co-opted for a new task through "cultural neural reuse"—a useful term covering probably much but not all of the story, because culture acts reciprocally on a person's literacy, and many parts of the body are changed consequently. Knuckles are harshly rapped for some left-handed writers, and in slave and rigidly gender-stratified social systems, literacy can mean fear and possible death. This harshness itself suggests the critical importance of literacy in the development of moral humans.

Colagè reveals that culture changes the body every time someone learns to read. Culture changes tissue. Reading is not some superficiality layered upon a biological substrate, but actively *creates the body* so the body functions differently. If culture is not actively present, the left FG2 does not perform its new function. The biologically based capacity for culture—that adaptation *par excellence*, which is, itself, embedded in all human (and chimpanzee and Neanderthal) genomes—changes the body in part through neural reuse, so that a neural network has a new component (2015, 1011). "Isn't it a beautiful example," Colagè asks, "of the strict entwinement between the material/biological and the mental/cultural dimensions of the human being?" (2015, 1014). Our not-so-simple answer is, "Yes, stunning, if one considers how many times this may have happened." We conclude, "Culture and biology have evolved in tandem as a single system."

Questions on the origin of the left FG2/reading connection suggest a need to model culture, biology, and evolution in new ways. Modern cognitive science, neuroscience, information science, and genomic science will help. However, when Colagè distinguishes "non-evolutionary" (like changes in the FG2 tissue of a single reader) and "evolutionary" (changes in the genome), we prefer to see that it is hominin brain plasticity that is truly under the pressure of natural selection. It is a population phenomenon.

The plasticity of hominin biology is especially obvious at the genomic level, where chimpanzees and humans often use the same base sequences (or the same sequences transposed, or different numbers of copies of the same sequences, or the same sequences in different "neighborhoods" of the genome) to express different phenotypic results (Varki and Altheide 2005). The genetic material of the human and the chimpanzee is now estimated at 96 percent the same, down from a higher initial estimate. What appears to be the same genetic material on two related species' genomes is often expressed phenotypically in very different ways. The position of genomic material next to or far from an environment of active change, and epigenetic influences that are not part of the genome, can alter protein synthesis. Most genomic sequences do not encode proteins at all, but regulate their production, and more. Researchers are discovering that much of the difference between us and our closest relatives is found not in genomic structure, but in how it is expressed.

Culture's changing of the body, so delicately proposed by Colagè, is not new to those of us who have engaged in anthropological field work or other activities with indigenous peoples (which the two authors have done). We wonder about such things. We know that the very different culture of the people we work with has changed their bodies. We know it intuitively and our colleagues study the mechanisms and cope with the results. People perceive differently, they react differently, they fail to be moved by stimuli which to us are strong, they overreact to stimuli that we barely notice, and they die of diseases for which our science has no definition. Culture functions to guide people's attention toward specific entities, like animal tracks or storms or ghosts, or specific tasks like storytelling or reading. Brain tissues change, neural networks shift, and new functions are created on a flexible neural infrastructure.

When we consider the full import of Colagè's work, we see that the continuing development of humans on Earth is not quite as simple as a full-scale adaptive transition from biology to culture. We see that it is more complicated and that *it is still occurring*. Colagè's findings show clearly that there can be no single time point when biological adaptation fell away and cultural adaptation took over. Indeed our evolutionary lines have always had a capacity for culture, if we interpret our connection to chimpanzees correctly. Culture has always been there, although, for us, it has grown enormously in capacity and importance over the past 7–8 million years, since we parted with the common ancestor to us and the modern chimpanzee. The context in which culture is expressed has changed, both biologically, in terms of growing and changing brain capacities, and environmentally, as culture both shields humans increasingly from the vagaries of climate, predators, and disease, and exposes them to worse. The relationship between biology and culture shifts, and the results of many changes are written in the biology itself (as in the left FG2), and in the genome at the base of it—which, we should remember, has inherent time functions embedded in it, such as mutation rates and association with Human Accelerated Regions (genomic HARs).

NATURAL SELECTION OF PLASTICITY

Plasticity is essential in grasping the distinctiveness of the modern human species at this juncture in our ongoing evolution. We believe it is the high degree of biological and cultural plasticity of our line that sets the stage for the emergence of the first moral systems in an earlier, successful member of the genus *Homo*. Moral systems are at once firm and precise, but ultimately flexible. They provide a mold in which the complications of life can never perfectly fit. No other living primate (including the chimpanzee) has the same plasticity, nor does any other species have morality. Even after a decade of paying homage to the extinct Neanderthals, and rightly revising the prevailing view of their culture as somehow inadequate, they remain—in both their fossils and in the research literature—less plastic than modern humans. Is this a matter of some *sapiens*-centric way of thinking? We believe it is not.

Research by Tononi and Cirelli provides a good example of the ways in which plasticity is being examined by modern neuroscience. They evaluate the thesis that "sleep is the price the brain pays for plasticity" (2014, 12), and find that neuronal homeostasis is apparently regained during sleep, which improves memory and integration of learning. This modern neuroscience supports the theory put forth by Frederick L. Coolidge and Thomas Wynn (2009) that *Homo erectus* achieved substantial cognitive gains from a new lifeway that was completely terrestrial, including good and longer sleep, REM sleep, heightened creativity, and improved learning and memory. All of these changes help to form a solid platform for our contention that the learning context we call the "Human Hearth" (defined fully below) was strong enough to support the emergence of moral systems, and eventually the application of morality to new instances.

Our human lineage continues to emerge as more supple, more elastic, more resilient than the others—more plastic. Scientists and philosophers independently conclude that humans are very flexible—which means different things for the genomic scientist, the palaeobiologist, the ethologist, and the cultural anthropologist. In observing the *opposite* of "flexible," philosopher Philip Kitcher (2009, 120–39) finally uses the term "stuck" in his critique of Veneer Theory (that morality is a thin veneer over an instinct-driven biology). He questions the adequacy of "psychological altruism" as a useful proxy or precursor for "morality" in De Waal's studies of chimpanzees (2009). Kitcher 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. (2009, 135)

Kitcher appears to flounder for the right word, arriving at "stuck," which we all understand, if only intuitively. To overcome this scarcity of both language and understanding, we conclude that plasticity, its nature and origins, require extensive further study, down to the level of cognitive science, neuroscience, and genomic science. And, what, for example, does "stuck" imply for information science? Just as important, we glimpse in Kitcher's above complaint how important plasticity is to a satisfying definition of morality. Plasticity and morality seem to go hand in hand. Moral systems could not take hold in a line of animals that was rigidly bound to pre-patterned behavior, like the so-called "social" insects or instinct-driven birds.

We suggest that plasticity itself is a result of natural selection, and the latest research in neuroscience seems to support the contention that it is ultimately a biologically based capacity (e.g., Tononi and Cirelli, 2014). Future and ongoing research will involve additional, in-depth comparisons of the genomes of *Homo sapiens sapiens* and *Homo neanderthalensis*. Through the years, both before and after these species' genomes were reported (Chimpanzee Sequencing and Analysis Consortium 2005; Varki and Altheide 2005), there have been hints that plasticity may lie at the foundation of important differences between these two species of human. This is not to say that modern humans did not borrow some very useful genetic material by interbreeding with Neanderthals (Stringer 2012, 200). The notion is counter intuitive but it may be true. Neanderthal genomic material would have come to lie in an entirely different "neighborhood" indeed, after interbreeding occurred. It could well have been a good source of variability (Cochran and Harpending 2009).

Some Parameters for the First Morality

If the example of cultural neural reuse, the left FG2, and reading, is any measure, the flexibility of human biology is holding up well under an increasing pressure of natural selection, now and in the future (E. Harris 2015, 82–84). We might ask what new tasks will come along in the next six thousand years, while we venture into the remainder of our Solar System and on to new star systems. How many times will cultural neural reuse enable new perceptions, new abilities, and new understandings, while humans adapt to far more exotic environments than any challenge Earth has yet provided our species? The capacity for the human body and brain to change in response to culture should be reassuring, and yet we hesitate, because something must come along with culture-induced changes, and that is a mentality that questions how they will be used rightly.

To the anthropologist and the priest in us, these issues naturally lead us back to questions about origins and how the first moral systems emerged—this, in part to make sure that we can identify the capacity and determine whether the human species still has it available! At the same time that the concept of cultural neural reuse suggests questions about humanity's future, it may also provide a tool to begin exploring the emergence of the first moral systems. While forced and unethical neural reuse and genomic change may seem irrelevant at present, they will soon become issues because their implementation is not too far off. *Homo sapiens sapiens* will evolve further, but there are some things we do not want to lose in the process. It is at times like these that we are grateful that the biological capacity for human morality appears to be deeply sewn and not easily excised, like a "veneer." The view that it is essentially strong and deep is suggested, at a minimum, by the fact that the Human Lineage Specific (HLS) genomic segments that distinguish humans from chimpanzees are widely dispersed on all twenty-three chromosomes.

In many ways, our approach follows Francisco Ayala's understanding of human morality (2010). We, too, look backward into the evolution of the human species, rely upon Darwin's understanding of evolution as "descent with modification," and view moral behavior as "rational behavior." Ayala provides another solid platform from which we can work. At the same time, because of new findings in neuroscience, cognitive science, and genomic science, we end up with somewhat different conclusions. The discussion among philosophers, anthropologists, and theologians will no doubt continue, and it should prepare us well for the challenging times to come, when we encounter yet other intelligent species. Will they be moral creatures? Confronting this question can only help us set the stage for these encounters, and manage the consternation and confusion that will be forthcoming among earthly populations.

Morality, as a universal feature of both culture and, as we now see with Colagè's help, biology, has proliferated, but it retains certain features that are consistent and that probably derive from the context we hypothesize. The common birth of moral systems helps to explain why they all somehow seem the same, even if we cannot pinpoint exactly why, and even when certain features of this moral system or that one seem abhorrent. A model of the Human Hearth and its role in creating the first moral systems should suggest how morality came about and therefore allow us to recognize it for what it fundamentally is. The original African environment is known—woody but not forested, with open grasslands. We know the outline of the biology and lifeway of a species which was successful for a very long time throughout Africa and then on the Eurasian land mass. Coolidge and Wynn (2009) propose that *Homo erectus* was the first completely terrestrial species in the genus *Homo*, and that had a far-reaching effect.

Two philosophical commentators to Frans De Waal's book on primate studies (2009) argue from different viewpoints that chimpanzees' mutually helpful social behavior patterns, cooperation and kindness, and their so-called "altruism" do not equal human morality. Why? Because the latter implies so much more. Paraphrasing Philip Kitcher (2009, 120), the question becomes, how do we "get here from there"? Focusing in part on internal, self-conscious moral construction as the key, Christine Korsgaard writes that "the distinctive character of human action gives us a whole different way of being in the world" (2009, 117). In teasing apart this difference, we understand that human morality includes a type of regretfully dispassionate reasoning, a tentativeness that derives from the inner balancing act we have just mentally performed, a sometimes sad rejection of "wantonness" (a term from Frankfurt 1971), and often an empathy with a person receiving moral judgment. Moral reasoning carries a burden and a weight. A simultaneous consideration of the "good" for everyone, including oneself, is a mental leap that the great apes have not made. Korsgaard corrects the nature of higher ape social behavior:

> [I]t is also absurd to think that nonhuman animals are motivated by self-interest. The concept of what is in your own best interests, if it makes any sense at all, required a kind of grip on the future and an ability to calculate that do not seem available to a nonhuman animal. . . . Animals are not ignoble; they are beyond moral judgment. (2009, 102, 118)

Morality shows up better, we believe, in Colagè's literate, left-FG2-tissue bearer who is struggling to read a sacred text, or in the priest's quiet confessional, than in all the social and political machinations of all the chimpanzees we can study in the wild. Their social behavior is not enough to derive morality, which is a human feature that is distinctly unique. Primate studies are important and will be more so in the future when we can better link social behaviors to specific tissues of the brain and segments of the genome, but they cannot unveil morality where it does not exist.

A change occurred on the evolutionary lines of the genus *Homo*, but it may have happened more than once because the species taking its first step across the bright white line of morality existed for a long time, a total of perhaps 1.8 million years, in a variety of contexts in Africa, Europe, and Asia. Exactly when the change(s) happened is not clear, but that knowledge will be forthcoming in the future. We will be better able to time morality's emergence when we identify, as Colagè has in part, which portions of the brain are most involved in moral decision making, and for those tissues, which segments of the human genome have changed accordingly and how they operate today to produce the characteristics of human, phenotypic morality (Table 1). Once we identify the specific parts of the brain involved in moral capacity, we will be able to use the inherent time functions of the genome and, comparing our genome to that of our closest extinct and living relatives, determine approximate dates.

The compilation of the specifics has already begun, as we illustrate below. Yet, proving when individual components of our moral biology emerged will be enormously complex. Neuroscientist/philosopher Michael Gazzaniga (1999) describes the human brain broadly in these terms:

> [T]he left brain has modules specialized for higher cognitive functions, while the right has modules specialized for other functions. . . . In addition to the skills named above, our big human brains have hundreds if not thousands

Table 1. Phenotypic characteristics of morality in the human species

- 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"
- A capacity for empathy with someone receiving moral judgment
- The experience of a burden
- Resolution on the part of the group
- Hope and faith in the future on the part of the group

> more individual capacities. . . . What is amazing about the human brain is the sheer number of capacities.

The environment and social context we explore occurred at a time very different from the one Colagè considered, that is, since literacy emerged. We focus on an early human sociocognitive niche (Whiten and Erdel 2012), beginning sometime after one million years ago, after hominins controlled fire and no longer nested in trees (Coolidge and Wynn 2009, 107–50). We focus on a fully bipedal species who was already more advanced than the living chimpanzee, so the comparisons to living primates remain important, but limited.

Eventually, it will be possible to test the hypothesis that moral systems began to emerge in the course of the evolution of *Homo erectus*, after he learned to control fire—perhaps not make fire, but use it. With fire, the Human Hearth was established and, we argue, moral systems began to emerge in response to specific features of the new environment that a communal fire enabled and encouraged. The Hearth around which morality dawned is still precious to us today, long after our distinctly human moral features have been developing for a million years. The hearth remains "home" in every sense of the word. Perhaps recognition of its original role in the emergence of moral systems will help us better understand the enduring appeal of the campfire.

BEFORE THE FIRE

Homo erectus walked fully upright for perhaps a million years before the Human Hearth emerged, according to our model. The species ranged widely with a full stride, and was the first hominin to walk out of Africa and populate other large land masses (Templeton 2005; Stringer 2012). We propose that the Human Hearth arose after *Homo erectus* had learned to control fire.

However, until recently there was scant evidence for this because there are no charcoal pits until around 350,000 years ago. New evidence has emerged from work at Wonderwerk Cave in South Africa suggesting the control of fire and cooking by hominins, probably *Homo erectus*, at one million years ago (Berna et al. 2012). This archaeological site also necessarily poses the question: Did hominins control fire and cook at an even earlier date?

Coolidge and Wynn 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 (2009, 115). 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 . . . 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 . . . *Homo erectus* needed to feed its enormous brain. (2009, 115)

Homo erectus was not the first member of the genus *Homo*. However, there are only a few remains that document earlier species of *Homo* that emerged around 2.5 million years ago. While new "cognitive archaeologists" (Coolidge and Wynn 2009, 128–50; Coolidge et al. 2015, 182–86) propose that *Homo erectus* took a major "cognitive leap" by leaving behind the ape pattern of nesting in trees, sleeping soundly on the ground, and priming in specific sleep segments, something else important happened to earlier members of our genus. They scavenged for meat and it was that higher protein diet that helped to support a larger brain. Coolidge and Wynn phrase the earlier changes in a way that we have not seen before:

> The first hominin that palaeoanthropologists assign to the genus *Homo* . . . did have a larger brain. It was probably the maker of the earliest stone tools. . . . It was a small bipedal ape that almost certainly spent considerable time in the trees, including sleeping. But its adaptive niche included a greater reliance on meat acquired through scavenging, and *this dietary shift removed selection against large brains* [emphasis added]. This initially modest dietary change led to a significant grade shift in hominin evolution. This transition included a full commitment to terrestrial life (both sleeping and waking) and introduced a suite of necessary adaptations that resulted in the evolution of *Homo erectus* by 1.9 million years ago. (2009, 207)

Coolidge and Wynn also propose that the selection pressure *against* a lengthening Stage 4 (slow wave) and REM sleep segments, and, more generally, an extended sleep period of eight or nine hours, was *reduced* for *Homo erectus* (2009, 148). Said another way, Stage 4 and REM sleep were allowed to expand because the hominin could afford to remain asleep for long periods. The pressures against a larger brain—which are enormous because of the high levels of required energy and protein intake—were reduced because *Homo erectus* had an improved diet, including meat. Until this species emerged with an ability to range widely and obtain enough high-quality food, a large brain would have placed an energy burden on any creature, so it could not and did not develop. With the full-time descent of *Homo erectus* from arboreal life and an improved diet, the pressure of natural selection against a large brain was reduced, and his brain remained large and grew more complex.

Homo erectus had a larger cranial capacity than the australopithecines ("southern apes") who came before, with skulls averaging around 1000–1100cc, compared to modern humans with cranial capacities of 1300–1400cc. *Homo erectus* had a neocortex ratio (of the neocortex to the rest of the brain) that averaged 3.7–3.8, compared to a modern human ratio of about 3.9–4.0 (Aiello and Dunbar 1993, 188). Other features were just as important in illustrating the overall evolutionary trajectory of the human line—features that in the future would become even more pronounced. *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.

The leap in brain size from the australopithecines with 350–600cc, to *Homo erectus* with 1000–1100cc, is congruent with a need for sheer computing power to make complex moral decisions. In addition, the portion of the brain involved in complex decision making and long-term planning—the so-called "executive functions"—also leaped from an australopithecine neocortex ratio of 3.1–3.2 (*A. afarensis*, *A. africanus*) to 3.7–3.8 for *Homo erectus* (Aiello and Dunbar 1993, 188). These changes, including the possible establishment of a mental timeline, are congruent 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 is ultimately why the efforts to derive human morality from living primate social behavior always appear to fall short (Kitcher 2009; Korsgaard 2009).

Palaeobiologists estimate that the group size of *Homo erectus* bands averaged 100–110 individuals (Aiello and Dunbar 1993, 188). This is surely enough to require keeping track of a large number of social relationships, easily providing social stimulus for an enlarging brain (Dunbar 1998). The lifespan of *Homo erectus* was about 45 years at death, although some estimates are as high as the early 60s (B. H. Smith 1993; 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 100 square miles, or ten times larger than the home territory for the australopithecines (Coolidge and Wynn 2009, 117). Since the group was sufficiently large, individual males could be stationed as lookouts to protect against surprise attack by predators at night, while others slept.

Density of population and density of social interaction may be important factors in the emergence of moral systems. The number of problems that 100 individuals can encounter in a single day is staggering, but those requiring moral decision making are fewer. For problems that rose to a certain level of importance or sank into a morass of confusion, there could have been ample opinions on "the right thing to do."

In addition to his brain, *Homo erectus* had yet one more important mechanism for weighing decisions. We assume that *Homo erectus* had some form of language or proto-language. At the beginning of the species' time on Earth, 1.9 million years ago, the hyoid bone in the throat had already assumed the squared-horseshoe shape of all in the human line, which indicates a change in vocal structure and mechanism. That shape arose long before, beginning about 2.5 million years ago, close to the time that the genus *Homo* originated. There seems to be general agreement among palaeobiologists that language took over to cement social relationships while grooming declined. Dunbar proposes a level of 30 percent of time, when grooming should decline and language arise, and that this level occurred during the time of *Homo erectus* (1996, 114). Alan Barnard writes, "Language became a selective advantage, and enabled communication within and between groups. A primitive language should in turn allow migration, including the *Homo erectus* expansion from Africa along the coast to South and Southeast Asia a million years ago" (2008, 233). Some form of speech may have helped *Homo erectus* create new ideas, but, equally important, arbitrate them in a moral context. It is also noteworthy that *Homo erectus* expanded out of Africa at about the time that we are proposing the species learned to control fire, and the first moral systems emerged within the context of the Human Hearth.

Homo erectus was larger than the earlier australopithecines, and sexual dimorphism (male/female difference) was much reduced. Females were larger and must have required almost as much energy as males (Coolidge and Wynn 2009, 116–18). The number of calories consumed by both males and females increased, in part to feed a larger brain with higher quality food, especially meat. The diets of *Homo erectus* had more protein, probably due to "aggressive scavenging," but there are only a few sites that confirm this (Coolidge and Wynn 2009, 118). The need for energy by larger, pregnant, and lactating females may have been partially met through food-sharing by the mother's mother. Kit Opie and Camilla Power (2008, 176) use time data on the eruption of the third molar for chimpanzees and human forager females to estimate that the age at first birth for *Homo erectus* females was 16.8 years. Using similar data, they estimate the age at last pregnancy was 33. If females lived to 45 years, that would give them 12 post-reproductive years.

Menopause is an unusual biological feature, although universal in humans (Varki and Altheide 2005, 1747–48), and it may well qualify as a Human Lineage Specific (HLS) trait (cf. O'Bleness et al. 2012). Long postmenopausal life segments differentiate humans from other primates (Hawkes et al. 1998). One proposed explanation for menopause (the "Grandmother Hypothesis") is that postmenopausal females provision their daughters and thereby improve the likelihood that their own genes will survive. Since menopause reduces the grandmother's own fertility, the hypothesis is very interesting from an evolutionary perspective, and might best be seen as an advantageous trade-off. James F. O'Connell, Kristen Hawkes, and Nicholas G. Blurton Jones try to correct a common image of *Homo erectus* as having "family provisioning by men," and offer an alternative theory that female foraging and food sharing contributed substantially to the "appearance, spread, and persistence of *H. erectus*" (1999, 461). Sharing food among different men, women, and children led to mutual obligations between families, and the daily details of social reciprocity formed a strong, structured network between members of the band, which is now commonly referred to as "a kinship system."

Theories about menopause appear unsettled, but it seems that *Homo erectus* females may have had considerable time after their fertile years to contribute to the group—their daughters and others. Our view is that females not only contributed food and skills, but ideas. This leads 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 elder 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"?

Longevity—another phenotypic human trait noted by biologists (Varki and Altheide 2005, 1747)—has been closely linked to the long-standing notion that menopause is an adaptation (Williams 1957), and that there are critical social and food-sharing functions for postmenopausal females. The role of the grandmother signals a shift away from a provisioning pattern more typical of apes to one typical of "the first widely successful members of genus *Homo*" (Hawkes 2003, 380). 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).

With a longer lifespan, it seems logical that a number of elders, each with a knowledge base on life's problems and solutions, would enable a standard method for arbitrating new instances. 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 a plurality of the elderly, which were available in longer lived bands of *Homo erectus*. Younger members of the band would learn from the elders, and be sanctioned by them. A key feature of morality has always been wisdom, which usually does not emerge until well into adulthood, if at all, so we find that 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 indiscriminate action—from "wantonness." We have suggested ways in which his biology—his loss of sexual dimorphism, the development of menopause, the role of mother's mother in provisioning, the species' longevity, the ability to sleep well, dream, and practice solutions during his waking hours—all made a structured and shared culture a good possibility. 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.

We have seen in Colagè's example of reading that this incorporation of faculties and transition to abilities that enable and encourage morality need not be all-or-nothing. It can happen in degrees. In fact, we would hazard a guess that the biological capacity for morality is not yet, even in *Homo sapiens sapiens*, completely "hard-wired," just like reading is not. The left FG2 tissue, without a proper stimulus, can simply revert to its original purpose of reading faces. Perhaps other tissues related to morality do the same.

When we consider *Homo erectus*, who came relatively early in the evolution of our genus and prospered for more than 1.8 million years, we can better understand the possibility of a unified nature for human morality from one culture to another. Indeed, neuroscientist-turned-philosopher Sam Harris defends a universal, scientific, and common sense approach to the evaluation of moral systems. He puts his rejection of cultural relativism the following way, which seems all the more compelling given 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's "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. Harris (2010) writes,

> I make the case for a universal conception of morality . . .
>
> When I speak of there being right and wrong answers to questions of morality, I am saying that there are facts about human and animal well-being that we can, in principle, know—simply because well-being (and

> states of consciousness altogether) must lawfully relate to states of the brain and to states of the world . . . . I believe that we can know, through reason alone, that consciousness is the only intelligible domain of value. What's the alternative? . . . well-being is what we can intelligibly value—and "morality" (whatever people's associations with this term happen to be) *really* relates to the intentions and behaviors that affect the well-being of conscious creatures . . .
>
> The moment we admit that consciousness is the context in which any discussion of values makes sense, we must admit that there are facts to be known about how the experience of conscious creatures can change.

Without a doubt *Homo erectus* had consciousness, and probably self-consciousness. They were enabled by a brain that was twice the size of the brain of the australopithecines.

What we will now search for are findings from neuroscience and cognitive science that make the emergence of moral systems in *Homo erectus* logical in relation to his lifeway and his struggle to survive. At this point we find the still-tentative conclusion appealing that morality, or a capacity for the development and use of moral systems, is ultimately a biological adaptation. It is an adaptation that different cultures use in different ways, but which remains universal and the same across the modern human species, as long as the proper stimulus is present. Morality as a biologically based capacity finds support in Colagè's example. If the stimulus of reading is present, the left FG2 oversees reading along with other components of the brain, and gives access to the self-knowledge and transcendence that emerges from reflective reading.

What we find staggering, when we contemplate the full breadth and depth of morality *vis-à-vis* Colagè's circumscribed but essential and important capacity, reading, is that there must be so many more human capacities that fall within the operation of a moral system and may have been subject to mechanisms like cultural neural reuse. If Gazzaniga's assessment of the number of individual brain capacities is as large as he estimates, then morality must surely draw on a fair number of them, and the complexity of operation of the moral system must be universal, global, and variable, but very finely tuned from instance to instance.

MISSING FROM THE MODEL

Important features for an origination of morality in *Homo erectus* remain missing—both environmental and cognitive. Here, we explore a new understanding of the ecological importance of African savannah grasses in natural burns for hominins who may not yet have been able to make fire, just obtain it. Second, we delve into the origins of a hominin cognition that could have supported moral systems, and identify their essential components. To do so, we will use concepts from modern cognitive science and neuroscience.

In the theoretical discussion of fire, we note the growing dominance of the more evolutionarily advanced and efficient C_4 grasses (cf. Edwards et al. 2010; Ripley 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. C_4 probably evolved more recently. Where C_4 grass 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. If the species *Homo erectus* was reliant on natural burns as a source of fire, then it was fortuitous that the often more flammable C_4 grasses predominated in parts of the African savannah during the species' tenure. Laura Attwell, Kris Kovarovic, and Jeremy R. Kendal (2015) write, "The savanna mosaics and dry forests of Africa where early hominins evolved, characterized by an increasing amount of flammable C_4 grasslands, provided the perfect conditions for natural wildfires." They go on to point out the concurrent emergence of C_4 grasses and the human lineage. We believe that because C_4 flammability was so important to natural burns, and controlling fire was so important to a lifeway centered on the Human Hearth, C_4 grass domination must be considered in the ecological system giving rise to morality's evolution.

In terms of cognition, the principal missing piece from our model is an arbitration mechanism that operates along a timeline. When we discussed the leap in brain size from the australopithecines to *Homo erectus*, especially the relative size of his neocortex, we mentioned the possibility that his brain had become sufficiently robust to conceive a timeline. If true, and we think it is, then he could calculate past and present events, and weigh them in planning future action. His careful construction of stone biface tools suggests he preconceived a three-dimensional image of the hand axe he used, and mentally staged a series of construction steps that could only be called a "standard process." A process implies a timeline, from the conception, through steps of preparation, to use of the final product. *Homo erectus* could do that, and very well indeed. Therefore, we feel it likely that a timeline was well within the cognitive capacity of the species, and that he used it for moral constructions, too.

The technology of *Homo erectus* suggests that he probably did not exist simply "in the moment"—a feature often used to distinguish humans from other animals. Stems, stones, and blades of grass are used by higher apes in an *ad hoc* fashion, but multi-step construction of tools is the province of humans alone.

Given a cognitive timeline, we ask: Is there any finding from neuroscience that suggests the human mind contains an explanation maker that works along a timeline, sifting information from past and present, and projecting consequences into the future? Is there a faculty that attempts to explain cause and effect, why things happen the way they do, and how they might happen in the future? Yes, it is the Left Hemisphere Interpreter (LHI), which has emerged from decades of neuroscience research (Gazzaniga et al. 2013). The LHI represents a brain function that organizes experience in this way, although the LHI is not inherently science-based. It simply makes up explanations. Gazzaniga puts it this way: "The left hemisphere's capacity for continual interpretation may mean that it is always looking for order and reason, even where there are none" (1999).

Homo erectus was under selection pressure to develop stone biface tools to help him better process kills, or meat and hides from the kills of the large cats, quickly and efficiently for eating, cooking, drying, and storage. Tools were also useful in processing some plant foods, and once the species controlled fire at around one million years ago, these activities became part of preparations for cooking. In general, well-made stone tools were an aid in obtaining sufficient nutrition for the large brain of *Homo erectus*. However, what is the use of the LHI?

In terms more consistent with the way evolution works, if an LHI were present, it is difficult to see that it was not used, and if it were used, then it was applied to past and future action along a cognitive timeline—a timeline that multi-step stone tool construction had already cemented. The LHI was also a great help in improving reproductive chances through "mind reading" and calculating opportunities.

At first, it might seem that the LHI's tendency to find explanations, even if they were not realistic, would be a disadvantage. However, it is useful to remember that the species lasted over 1.8 million years. Our species, *Homo sapiens*, has been around only 200,000 years, so we have a way to go to match the staying power of *Homo erectus*. Over time, *Homo erectus* must have been well able to vet explanations in reality, just as we do. If an explanation of a weather pattern was faulty, experience had a way of testing it, so the neocortex was continually correcting explanations in a way that would approximate, if not match, science.

To beings with a scavenger-gatherer economy who needed any clues they could get as to how to feed and protect themselves, both a timeline and an explanation maker would be invaluable—even though, as we see from Gazzaniga's research, the explanations sometimes hold little connection to a science-based reality. The LHI, as a continually explaining voice in each of our heads, has similarities to Adam Smith's "internal spectator" or "impartial spectator" (Raphael 2007; A. Smith [1759] 2013), or "a conscience" in Judeo-Christian theology. And yet, while these operators might be called "impartial," it is important to remember that for *Homo erectus* the productions of the LHI would necessarily be vetted against a valence from "good" to "bad." For a species that must have operated often on the very edge of existence, one positive endpoint must have been survival—and not death.

To this point, we have not identified a cognitive mechanism from modern neuroscience that would provide a capacity to evaluate different explanations produced by an LHI, and be available to vet behaviors, in general, against each other. Moral capacity would depend on such a mechanism because morality implies a sometimes complex evaluation of both mental and behavioral options and deciding about alternatives.

An arbitration mechanism that could have been used by *Homo erectus* is suggested by other research in neuroscience, which provides evidence for connections between REM sleep, affective executive functions, and evaluation—or, arbitration (cf. Gazzaniga et al. 2013). The following comment by Coolidge et al. (2015, 184–85) suggests a cognitive capacity through which various explanations derived by an LHI (in a context we might call "science"), or multiple mental or behavioral options (in a context we might call "morality"), were vetted by *Homo erectus*.

> Franklin and Zyphur (2005) . . . proposed that dreaming may not only serve to simulate ancestral threats but may also serve as a more general rehearsal mechanism for scenarios encountered in daily life, subsequently and positively influencing waking encounters. Such a mechanism would facilitate decision making without significant influence from conscious awareness or language. If this hypothesis is correct, dreaming may have played a more important role in *Homo* evolution prior to the advent of language. Physiological evidence for the hypothesis comes from the activation during REM sleep of the ventromedial prefrontal cortex (PFC), amygdala, and anterior cingulate cortex, which mediate some of the affective executive functions and are thought to play a strong role in social and interpersonal decision-making and evaluations (e.g., Gazzaniga et al. 2013).

It is especially interesting to note here that some *affective* executive functions are mediated through this neurological complex. We have hypothesized elsewhere that affectivity is fully integrated into rational decision-making and even scientific modeling (Rappaport and Corbally 2016). Indeed, the presence of any neurological, hominin evaluation system could well be founded on affective—as well as rational and "scientific"—determinations. This would explain why some options "feel right" and "seem right" even when we cannot verbalize the full process behind our judgments.

The way in which use of a timeline, the LHI, and the above arbitration mechanism were integrated into a truly more impartial, cultural evaluation system—morality—is the story of *Homo erectus* and the Human Hearth, and all of the hominins in the evolutionary line to modern humans. Not only was survival to be valued over death, but later satisfactions would accumulate a positive valence, including warmth, the group feast, conviviality, sexuality, the entertainment of a good story, pride in one's family and the group at large, the excitement of discovery and of the hunt, and eventually, justice, ethics, mercy, obedience, and religious transformation—or as Colagè termed it, transcendence.

The work of the LHI and the common arbitration mechanism may also be connected to the reason that all moral systems seem somehow the same. We must return to the lifeway of *Homo erectus* to understand how this worrisome, sad, regretful, self-conscious arbitration system embodied (perhaps literally, through cultural neural reuse) at the service of a moral code came under positive selection pressure. When it first emerged—very likely through genetic drift in relatively small populations of hominins (E. Harris 2015)—what were the signs that the LHI was an advantage? It might have been interpreted as a malady, and indeed the shaman (or seer) in many known primitive societies often has the burden (or advantage) of being a bit "unbalanced." He or she can find it necessary to go into trance or some other altered state of consciousness like sleep, in order to reveal what he or she "sees and knows." Other members of the group conclude that this revealed knowledge must be—it is rightly reasoned by the handy LHI that knows no science—a gift from the spirits, knowledge from some supernatural place.

Philosopher Christine Korsgaard writes that "human beings seem psychologically damaged, in ways that suggest some deep break with nature" (2009, 104). Morality does indeed represent a sharp break with the past, one that contains within itself stages of conflict, doubt, and sadness, but whose operation serves ultimately to resolve tensions in the group. Grooming might be used to resolve tensions between two chimpanzee coalitions, but morality is much more, operating at a different level to arbitrate difficult existential questions whose resolution is critically important for the group to adhere as a unit and not lose hope for the future. Once morality has been applied, the group can "go on," however regretfully.

Therefore, we propose that morality is just as natural as sociability, but it exists at a higher level of both complexity and operation. It is much easier to explain blatant self-interest and instinct-driven passions, and so much easier to interpret coalition building and food exchange among chimpanzees, than it is to understand the quiet constraints of morality, which are, in the end, so often more effective in getting what each of us wants and what the group desperately needs. With morality, the need for grooming vanished, although the need for human touch did not—in fact, we propose that it became more accentuated. The human line may have developed a softer, finer fur not just because it aided cooling, but also because grooming was gone, replaced by something much better to give all members of the group hope. It is useful to remember that humans have approximately the same number of hair follicles as the gorilla. We simply went on our separate evolutionary paths, in many more ways than one.

AN ESSENTIAL FEEDBACK LOOP IN COGNITIVE EVOLUTION

Evolutionary science abounds with "chicken and the egg" questions, which then set up modern theory for supposed instances of Wallace's Conundrum. We note above the question about literacy and the ability of the left FG2 tissue to switch over to a new neural network that guides reading. We discuss biological and cultural plasticity, whose boundaries are becoming even more indistinct with discoveries of the ability of culture to change biological tissues. Eventually, it becomes difficult to separate biological and cultural evolution, and in the emergence of morality we may have one of the best examples of their interconnectedness.

In light of the modern neuroscience described above, we are forced to ask: How did this capacity to develop moral guidelines and apply them emerge? Was it a biological change or a cultural change? The question is not quite as unsolvable as it seems at first. Eventually, the genomic basis for tissue like the FG2 will be better understood, and eventually we will be able to estimate the timing of changes in it and other brain components involved in morality by comparing them to the genomes of our closest relatives, both living (like the chimpanzee) and dead (which are closer). Some of this will emerge with better technologies for reconstituting the DNA of palaeoanthropological specimens. Until that time, we are still faced with the task of modeling the interaction of biological and cultural evolution, and it is very likely in the species of *Homo erectus* that the switch from one to the other speeds up. When it speeds up enough, we have the emergence of *Homo heidelbergensis* and later, *Homo sapiens.*

An example of the task of modeling the interaction of biological and cultural evolution emerges from recent work on so-called external storage systems, incisings on clam shells and ochres, writing, and other products that compress information in culturally fabricated artifacts. From the point of view of information science, this is surely one of the best tricks that hominins have devised—to store information outside the brain and then potentially to manipulate it later.

Our view is that there may have been long lags between the first emergence of biological characteristics and the use of them by a hominin culture. This is the source of our reasoning that morality may have emerged more than once during the 1.8 million years that *Homo erectus* was a living species. One of morality's components may have emerged and remained unused, potentially many times. The species had a long time to evolve with biological components that allowed the cultural invention of morality. The biology always comes first, even if it is not used. This is a fundamental principle of Darwinian evolution. There is no vast force that planned for morality and somehow allowed its emergence by tweaking this brain component, and then that one. It is random, but the process had a great deal of material with which to work in the genomic plasticity of the human lineage.

Our requirement is for morality to be underpinned by “an arbitration mechanism that operates on a timeline.” Without this, morality makes no sense, either now or in the past. Morality takes a lengthy view, it weighs behavioral options, and it makes decisions. Our requirement can be separated into at least three components: a timeline, a multiplicity of options, and an arbiter. The stone tools of *Homo erectus* prove the first. The multiplicity of options could be provided by an emergent LHI. The arbiter involves the evolution of a network of brain components operating to evaluate options and make decisions, as Gazzaniga et al.’s (2013) work suggests. It could well be that these three components did not always emerge at the same time. It was a matter of chance that all three of them emerged at once and became operational.

We propose that the best chance for these three components to emerge together and be used to develop moral systems occurred after *Homo erectus* learned to control fire. The social context of behavior changed in a band of a hundred-plus individuals that was lit, warmed, and protected by a communal fire. We connect this context below to different types of culturally based behavior: religion, morality, kinship, teaching, and learning.

Returning to external storage systems, for which there are only a very few *Homo erectus* examples (Joordens et al. 2015), we propose that once they were invented—even by accident—they became part of the environment to which the species adapted biologically as well as culturally. Many analysts have wondered: Did these information storage inventions, once they got started, encourage their own further emergence biologically? Culturally? Yes, of course, on both counts. How do we know? Because we see the same thing happening all around us every day. We are so much like *Homo erectus*, and they like us, at least in terms of enjoying the play that external storage systems encourage. Play has been around among mammals much longer than the higher primates have.

To summarize, biological evolution operates before cultural evolution picks up and partially takes over. Then, once cultural evolution emerges, it acts in a reciprocal manner on the biology of the species. It changes tissues, and these changes can be either tolerated or not by the species. More than simply being tolerated, morality has enormous advantages for the human lineage. It simply took a long time for all the components to be present at once, and for a social context to nurture the nascent development of morality. *Homo erectus* had a long time.

The Human Hearth and the Circle of Light

Psychologist Frederick L. Coolidge and anthropologist Thomas Wynn (2009) provide some basis for our conception of the Human Hearth in their theory derived from cognitive science. Their approach is to use the now-substantial knowledge base on modern human cognition—derived largely from laboratory testing—and look backward with it to try to understand earlier hominin species. It is a brilliant, creative approach that allows researchers to begin understanding the psychology and, we propose, the morality of earlier human species. It provides a basis for investigation, if not proof.

As noted, Coolidge and Wynn propose that *Homo erectus* took a "first major leap in cognition" by transitioning to sleep on the ground, rather than nesting in trees like apes do most of the time (2009, 128). At first, this seems puzzling. How could a change in the location of sleep make such a difference? Because arboreal ape nests, while they may be called "engineering masterpieces," are not extremely stable, so awaking to readjust and look around, just to make sure one remains in the tree rather than falling from it, is a real issue. Fossils have been found with broken limb bones. An insecure perch encourages light sleep.

In spite of this, would predators not make the move to the ground counter-productive? *Homo erectus* arose about 1.9 million years ago, and the control of fire appears to have occurred around a million years ago. We feel that the transition to ground sleep occurred before *Homo erectus* learned to control fire, but this is all the more reason *not* to transition to sleep on the ground. Since the publication of Coolidge and Wynn's *Rise of Homo sapiens* (2009), Kathelijne Koops and colleagues have conducted field research on nesting patterns of chimpanzees in the wild. About twenty percent of the time chimpanzees sleep on the ground, even when predators are in the area (Koops et al. 2012), and chimpanzees do not have the advantage of fire. Therefore, it appears reasonable that *Homo erectus* transitioned to sleep on the ground, leaving the light, interrupted sleep of apes in arboreal nests, during which full relaxation was not possible, because of the enormous advantages of good sleep for learning, creativity, and a different kind of social life. Did this change in lifeway affect morality?

The pay-off for transitioning to sleep on the ground must have been worth it, cognitive archaeologists argue, in terms of long sleep, sound sleep, and REM sleep, which appears to be a newer evolutionary development compared to other sleep phases (Coolidge and Wynn 2009, 128–50; Coolidge et al. 2015, 182–86). They write that sound sleep with full muscle atonia may well have encouraged learning consolidation and creativity in *Homo erectus*. These authors review the literature on sleep, learning, and creativity, and find that some results are solid, but others are not conclusive (2009, 143–49).

Around the time of the publication of Coolidge and Wynn's 2009 book, a paper appeared by Cai and colleagues (2009) which showed that slow-wave sleep and the second part of REM sleep are particularly helpful in improving creativity by "priming" associative networks, and they confirm the positive effects of sleep on creativity using the Remote Associates Test with human subjects. The suggestion that *Homo erectus* enjoyed enormous advantages from sleeping on the ground received strong confirmation from these researchers. Several years later, Coolidge et al. suggest that "there may have been three specific evolutionary benefits for cognition from sleep on the ground: (1) threat simulation and priming, (2) creativity, and (3) procedural memory consolidation and enhancement" (2015, 184). We would add (4) emergence of early forms of the neurological complex supporting the executive functions of evaluation and decision making (Gazzaniga et al. 2013).

We believe that the transition to fully terrestrial life occurred rapidly because the consequences—surely a trade-off—were not as dangerous as they might appear if we use Koops's findings on chimpanzees as a guide. Indeed, we believe that if bands of *Homo erectus* ranged upward to 100–110 individuals, then that density alone—their noise and smell—might well have warded off predation by all but the largest animals. A quiet animal is usually an animal safer from predation, but in this case, the opposite may have been true.

After *Homo erectus* learned to control fire, we propose that the Human Hearth became the focal point for human social and what would be moral life. This is a vastly different lifeway compared to australopithecines and living chimpanzees that nest in precariously made platforms of different trees, and must call out to each other when nesting in order to unify the group. Sleeping together is an intimate experience for humans, bonding them in ways unknown to the dispersed apes that sleep individually in trees or on the ground.

Equally important, the Human Hearth gave life a physical focus that was defined by a circle of light from the fire. This location (which may have moved from time to time within the hundred-square-mile territory of *Homo erectus* for purposes of sanitation, if nothing else) became a cradle, a warm resting place after injury or illness, a place for relaxation, a theatre, a workplace, a courtroom, and a place to enact rituals. The ring of light focused all members of the band. It became the place to which they would all return. It gave warmth, family, friendship, storytelling, food, and not least of all, a place to arbitrate difficult decisions with all present. It is worth noting that the effect of a campfire to mesmerize onlookers is well known, and Coolidge and Wynn imply that this, too, had an effect (2009, 115). Hypnosis can aid certain types of learning.

The Dawn of Morality

Because of the changed lifeway of *Homo erectus* once the species controlled fire, we propose that within a nexus of family relaxation and cajolery, aided by better sleep that provided an opportunity for social rehearsal, 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 campfire creates a sharp distinction between wild and tame, them and us, the un-touched and the culturally crafted or, as anthropologist Claude Lévi-Strauss termed it, "the raw and the cooked" (1975). 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 Human Hearth may have been one of the origins of the cognitive lag in human children. Sharon L. Thompson-Schill, Michael Ramscar, and Evangelia G. Chrysikou propose the following:

> The prefrontal cortex is crucial for the ability to regulate thought and control behavior. The development of the human cerebral cortex is characterized by an extended period of maturation during which young children exhibit marked deficits in cognitive control. We contend that prolonged prefrontal immaturity is, on balance, advantageous and that the positive consequences of this developmental trajectory outweigh the negative. Particularly, we argue that cognitive control impedes convention learning and that delayed prefrontal maturation is a necessary adaptation for human learning of social and linguistic conventions. (2009, 259)

We agree, and would add, "moral conventions, too," at an age when youth are ready. Indeed, we propose that it would have been useful for immature *Homo erectus* to remain unable to think quite so well 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 preformed to younger members of the band. Interestingly, this view receives recent support from a genomic scientist, Eugene Harris, who reminds us that "some molecular differences [between chimpanzee and human brains] seem to be related to the prolongation of development of the human brain, perhaps allowing our children to develop their brains over a longer period of time in rich experiential contexts" (2015, 110).

We propose that within such a context—that of the Human Hearth—an evolving LHI would derive explanations willy nilly, but then a polarity from good to bad was applied to evaluate explanations, in what would become a moral context. We are all aware of the drama that attends those moments when a son or daughter transitions to adult moral cognition. It can appear as a sharp transition in mental status, and such a transition must have challenged *Homo erectus* elders like it challenges human parents today. Nevertheless, by the time that age 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 had all come 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 later. The moral system that guided application of the code may not have been immediately present, but eventually individual band members would achieve a "suprasocial" level of evaluation and argumentation. They would individually be able to step back and look out from a higher perspective, and understand the instance-at-hand as one in a larger category of moral questions.

Cognitive capacities would continue to grow. Cultural neural reuse and changes in the brain would add a measure of security and stability for select perceptions, abilities, and capacities—as in Colagè's example of reading. The running explanation maker in the head of each member of the band, the LHI, would draw conclusions about cause and effect. 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 revolutions, as there are now, when an old way of thinking was thrown over by a brand new scheme. It would upset everyone, but eventually, if found useful, the ideas would survive and be incorporated.

THE SUPRASOCIAL LEVEL

Throughout this examination of the boundaries between biological and cultural adaptation, and our exploration of how they continue to operate in our ongoing evolution, we have referred from time to time to the "suprasocial" level. The plasticity inherent to the human line is striking in Colagè's example, but even more striking is the potentially enormous number of times this type of reuse of neural tissue may have happened in our evolution, and how many more times it may happen in the future. Ultimately, we feel that it is this plasticity which allows the emergence of yet another level of organizational complexity.

Moral codes are part of learned culture, emerging out of the dense fog of human social life and codified by elders or experts who can identify instances of similarity and probable solutions to new problems. However, the same plasticity that supported the human line's being able to read at such a late point in our development—only 6,000 years ago—also allows the application of a moral code to be variable. Moral codes constitute a mold that is constantly changing as the species encounters new and difficult challenges. The application of moral codes in a dynamic species—still evolving, still gaining new capacities, still encountering entirely new experiences—is difficult, and not many are sufficiently wise and experienced to do it. Those individuals operate at what we would call a "suprasocial" level. At that level, they know and take into account the full variability of the human species as they know it. They use moral codes as guides, but they can, in their most difficult moments, change things and allow new ideas and capacities to flourish for the good of all—not just one cultural group, but all cultural groups. This conception of humanity will be sorely needed if and when we encounter other intelligent species, and the few, the wise, will be called upon to decide whether to stretch our human moral system even farther to consider the "good" of the others, too.

NOTE

1. The Matrix Thinking approach (Rappaport and Corbally 2015) was used at several junctures and in several ways, in developing this hypothesis about the first rudimentary moral systems arising in *Homo erectus*.

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