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Running Deep: Speculations on the Evolution of Running and Spirituality in the Genus *Homo*

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Abstract

Recently, there has been a plethora of work that has cast *Homo*, possibly *Homo erectus*, as an established distance (endurance) runner. Speculations on selection for endurance running have focused on acquisition of animal protein, in the form of scavenging and hunting, specifically 'persistence hunting' (Carrier 1984; Heinrich 2001; Bramble and Lieberman 2004; Liebenberg 2006; Lieberman *et al.* 2006; Lieberman and Bramble 2007; Lieberman *et al.* 2007). This paper offers an additional explanation for the selection of endurance running (perhaps already established as a critical behavior that filled several facets of *Homo* lifeways, to include subsistence). Running in *Homo* selected for a Paleolithic spirituality or 'horizontal awareness' through a biologically based, culturally reinforced biophilia that would have been enhanced through the existing neurobiological reward system. This awareness or Paleolithic high provided *Homo* with a means to reinforce the necessity of running for survival and situate them as part of a larger and dynamic environmental universe. This intimate environmental bond was facilitated and communicated through running. To borrow on a contemporary evolutionary psychology assessment, humans are wired, both in body and mind, to be runners; however, the ultra running movement today is only a pale reflection of what would have been an essential and reflective part of *Homo* lifeways.

Diane Ackerman (2000) writes of *deep play* that departs from what many would consider the normal play of children, even adults. She suggests that deep play, such as rock climbing, biking, hang gliding, scuba diving, and so on, is characterized by feelings of rapture and ecstasy, which ultimately create an intimate bond between the player and the environment. As such, deep play is most often considered a sacred or spiritual activity by those who participate in it and has been an essential element driving our own evolution. We have borrowed Ackerman's notion of 'deep' to postulate the existence of a nascent running spirituality in the genus *Homo*. In this paper, we will refer to *Homo* as a generic designation for Lower to Middle Pleistocene hominins, including *Homo erectus.* Recent studies have identified many of the neurochemicals and brain regions stimulated during endurance running. These regions are tied into the reward pathway, a critical neurobiological component for developing and maintaining behaviors that are required for human survival and evolution. We speculate here that the existing biological reward system would have been enhanced through endurance running, driving the development of spirituality, since an expanding savanna and fluctuating climate (Bobe and Behrensmeyer 2004; Pickering and Bunn 2007) presented *Homo* with a paleoenvironment that selected for running.

Over time, our ancestors would have developed a heightened awareness of their environment that was characterized by an intimate and trusting bond that may have been the antecedent of *Homo sapiens'* spirituality. This early spirituality is believed to have developed in the Upper Paleolithic, only 40,000 years ago. The connection between spirituality and a heightened awareness of their environment would have provided *Homo* with a means to reinforce the necessity of running for survival and situate them as part of a larger, dynamic natural universe. To borrow a contemporary evolutionary psychology assessment, humans of all ages, both males and females, are wired, both in body and mind, to be runners.[1] However, besides the contemporary running cultures of the Tarahumara and East African runners (specifically the Nandi of Kenya's Rift Valley), the ultra running movement today is only a pale reflection of what would have been an essential part of *Homo* lifeways.[2]

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[1] Although for the sake of the thesis of this article we do not discriminate between amount of running and gender, or age—both males and females would both have utilized running in their lifeways. Childbearing and infant dependency would have certainly impacted running abilities and opportunity in females; however, over a lifetime, running would have been utilized by all. The difference in times in long-distance running in elite males and females is gradually decreasing—top women marathoners have broken two hours and twenty minutes, while elite male marathoners hover around two hours and five minutes.

[2] There is an increasing amount of work done on East African running dominance in world distance running (Manners 1997; Tanser 1997; Bale and Sang 1996;

Endurance Running

Endurance running in hominid evolution has recently been explored along the position advanced by Carrier (1984), Heinrich (2001), and Bramble and Lieberman (2004) that humans are uniquely constructed (as opposed to non-human primates and cursorial mammals) for endurance running (see Heinrich 2001; Bramble and Lieberman 2004; Liebenberg 2006; Lieberman *et al*. 2006; Lieberman and Bramble 2007; Pickering and Bunn 2007; Lieberman *et al.* 2007; Steudel-Numbers, Weaver, and Wall-Scheffler 2007). Endurance running is defined by Lieberman and Bramble as 'running many kilometers over extended time periods using aerobic metabolism' (Bramble and Lieberman 2004: 345). In addition to bipedal striding, there are unique skeletal and physiological features significant to endurance running that can be traced to *Homo* fossil remains.[3] The focus on running greater distances over an extended time period is an important distinction, since gait (or speed) and the ability to sustain this gait over time can be translated into an optimal energetic efficiency and cost to the individual. Bramble and Lieberman (2004) suggest that endurance running is a derived feature of the genus *Homo* and speculate that it originated around two million years ago. A series of four footprints similar to those of modern humans were recently found in Kenya and dated to 1.5 million years ago (Bennett *et al.* 2009). The footprints indicate a human-like footstrike and push-off of the big toe and the development of an arch, and according to Lieberman suggest that the owner of this foot was capable of running like modern-day humans (Joyce 2009).

Potential hypotheses advanced for selection of long-distance running center on subsistence, most notably scavenging and hunting. Heinrich (2001) and Liebenberg (2006) suggest that persistence hunting (running prey into exhaustion) would have been one of the subsistence activities of evolving *Homo*. Underlying the subsistence hypothesis is the notion that a defining behavior of the evolution of *Homo* was the increased intake of animal-based food into their diet, either through the scavenging of sinew, marrow, muscle tissue, and ligaments of carcasses or

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Burfoot 1999; Entine 2000; Mayes 2005;, and a plethora of popular articles in magazines and newspapers), suggesting genetic, environmental, cultural, social, and biocultural reasons for this dominance. However, work done on the enigmatic Tarahumara is basically from ethnographies of the Sierra Madre people (Bennett and Zingg 1935; Pennington 1963; Kennedy 1978) or descriptions of their running performance and games (Nabokov 1981; Merril 1988; Christenson 2002; McDougall and McClintock 2006).

[3] See Carrier (1984), Heinrich (2001), and Bramble and Lieberman (2004) for an extensive discussion of those skeletal and physiological features.

through actual hunting of prey. This acquisition of meat by early *Homo* has been posited by several authors as a means to increase energy availability to adapt to a more open horizontal environment (Bobe and Behrensmeyer 2004), to enable locomotion over larger areas, and perhaps the most consistently offered explanation, to acquire protein as fuel for an expanding brain (Shipman and Walker 1989; Milton 1999; Bunn 2001, 2006).

Bramble and Lieberman suggest that initially this type of subsistence strategy would have been 'too energetically expensive and low-yield for the benefits to have outweighed the costs' (2004: 351) due to lack of developed hunting tools such as bows, arrows, and spears, which would have minimized the effort in the chase. Instead, they posit endurance running developed in early *Homo* as a means to scavenge effectively protein-rich carcasses in an increasingly open and 'semi-arid' late Pliocene/Lower Pleistocene East African environment. Successful scavenging requires the ability to cover distance to the kill when olfactory and/or visual cues, including the presence of avian scavengers, are identified. Citing the lack of credible ethnographic examples (outside of Liebenberg's 2006 work), Pickering and Bunn (2007) question if hunting and scavenging selected for endurance running in African *Homo*. Scavenging for carcasses might not have been the confrontation or competitive event hypothesized by Bramble and Lieberman, but one that allowed access to carcasses for *Homo* in a more riparian environment (suggested by Pickering and Bunn to actually represent the African Lower Pleistocene) providing more cover for recent kills and less of a need to 'beat the carnivore rush'. In a reply, Lieberman *et al.* (2007), suggest that Early Stone Age *Homo* (*H. erectus*) was already capable of endurance running and this would have benefited efforts to scavenge and/or hunt, even if persistence hunting suggested by both Heinrich and Liebenberg was not primarily selected for by subsistence activity.

Scavenging and hunting were among several behaviors involving running that may have driven selection during a period when a fluctuating climate was expanding the Pliocene/Pleistocene East African savanna. Additional behaviors driving selection would have included a more active foraging strategy with greater daily-range transport of material and food items, communication, and play.[4] Here we suggest that endurance running featured prominently in the formation of a *Homo*-specific Paleolithic *horizontal consciousness*. Berman (2000) defines horizontal consciousness as a peripheral or diffused sense of ego through

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[4] See Sands (in press) for a discussion of running as a selective agent in human evolution.

an implicit trust in the intuitive 'laws' of nature. 'Consciousness' includes exploration and cataloging of the natural environment and the establishment of an intimate environmental 'trust', elsewhere referred to as *biophilia* (Wilson 1984, 1993; Kellert 1993, 1997, 2007). This horizontal consciousness is similar to Berman's (2000) comparison of hunting and gathering awareness differentiating early *Homo sapiens* from a more vertical spirituality and religion best corresponding to humanity after the adoption of more sedentary lifestyles about 10,000 years ago. We suggest that Berman's notion of a horizontal awareness applies with little difficulty to earlier *Homo* as well.

Reinforcing this relationship between nature and *Homo* was the neurobiological reward and pain response system. This reward system, engaged through bouts of endurance running, would have generated a heightened awareness or consciousness of the relationship between nature and *Homo*. This relationship was not framed in the duality of ego and environment suggested to describe human spirituality and religion for Upper Paleolithic *Homo sapiens* (Berman 2000), but instead defined an inclusive intimacy that would have featured no distinction between sacred and the lived present that would have characterized *Homo*'s lifeways. In essence, running, along with physical movement patterns of play, developed into ritual infused with awareness, or heightened consciousness, that reinforced *Homo*'s need to capture the essence of its natural resources for adapting and surviving in a changing environment. This heightened awareness would have hardwired the mechanism and expression of ritual into *Homo*.

Running was a crucial behavior that was keenly integrated into the fabric of Paleolithic culture and no doubt was instrumental in adaptive success to any number of differing environments, as the first *Homo* evolved and migrated out of Africa. A biological artifact or legacy of running in early *Homo* can be found in the so-called *runner's high* experienced by many endurance runners, from ancient Native Americans (Nabokov 1981) to contemporary ultramarathoners.

The Neurobiology of Play

Absent from discussions of the evolution of endurance running, or even the evolution of *Homo* in general, has been a discussion of running as play, and the corresponding effects of neurochemical releases, including endorphins, monoamines (serotonin, dopamine, and norepinephrine), and endocannabinoids. Play is a pan-mammalian behavior and has also been found in some reptiles (Burghardt 1998, 2005; Bateson 2005; Beckoff and Byers 1998). Much theoretical work exists that ties animal play to the evolution of human play (Pelligrini and Smith 1998; Bekoff and Byers 1998; Burghardt 1998, 2005; Byers and Walker 1995; Siviy 1998; Lewis and Barton 2004); however, little work has been done that focuses on what types of play would have been involved in hominin evolution.[5] Work on apes produces a picture of play that spans all four play categories: motor, object, predatory, and social play—with movement patterns that intimately feature running. For those mammals who are 'career' runners, such as ungulates, canids, and felids, running is an integral and critical component to each of these categories, including chasing, avoiding, and play hunting.

Recent work on the neurobiological responses to play advances theories that play is a critical component providing new and necessary stimulation during a critical period of rapid brain growth and development, when synapse generation and neural wiring is at its most flexible (Byers and Walker 1995; Burghart 2001, 2005; Lewis 2000; Lewis and Barton 2004). Play is also posited as training for the unexpected through 'kinemtic and emotional responses' (Spinka, Newberry, and Bekoff 2001). Siviy (1998) suggests that play enhances learning and stress relief, since neuronal connections increase in intensity following each play experience.

Neuroscientists who study human and animal emotion link specific neurochemical releases to the engagement and expression of play in rats (Panskepp, Siviy, and Normansell 1984; Panksepp 1986, 1993; Panskepp *et al.* 1987; Siviy 1998). As Siviy contends, 'dopamine, norepinephrine and serotonin are involved in the various aspects of play behavior'. In addition, play behavior in its expression and frequency through the juvenile period would 'alter the future sensitivity of these [monoaminergic] systems' (1998: 235). This suggests the more play, coupled with stress bouts, the more developed and sensitive to activity would be the release system. Siviy concludes, 'data suggest that social experiences during the age when play is most often observed can have an impact on the structure and function of those neurochemical systems, which appear to be involved in play behavior' (1998: 235-36).

In essence, from childhood through the juvenile stage, running and play would have been behaviorally coupled through self-expression and interactive bouts with playmates and the environment. These play behaviors trigger the reward pathway and modify neuronal connections within the developing brain, with juvenile play peaking during this

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[5] Hominin has becomes the classification for all living and past humans and their bipedal ancestors; hominid now refers to all humans, their past ancestors, and living apes and their ancestors (see Nickels 2006).

critical period of neural wiring. Play is also suggested to enhance the brain's ability to learn, as play can help build new neuronal connections. In this respect, play would promote creativity and ultimately provide a behavioral vehicle for increasing cognition (Siviy 1998). The expanding savanna would have offered a greater horizontal playground for juvenile play, rich with an array of environmental stimuli, along with the potential for danger that would have generated a never-ending continuum of unique play situations and high-stress interactions within the environment.

In comparison, Heinrich alludes to the movement activity in hunting as important in providing a necessary 'long term vision that both rewarded us by the chase itself and that held the prize in our imagination even when it was out of sight, smell and hearing' (Heinrich 2001: 178). Simply, it is the 'pull' of the hunt that propels the hunter into the future. Play theorists suggest that play offers a developing brain a smorgasbord of activity to learn from while influencing neural growth and rewiring. Indeed, social play, the more complex of play behaviors, seems to correlate well with neocortex size (Lewis 2000). Moreover, a co-evolutionary relationship exists between the cerebellum and social play (Lewis and Barton 2004), specifically in primates. Running would have been instrumental in creating the movement patterns necessary for play. Faced with a large array of environmental stimuli in such a risk-filled setting, *Homo* would have found cooperative play to be adaptive, serving to create, strengthen, and preserve social ties. Although theories advancing building stamina and physical strength as the primary function for play origins are suspect, running in play would have maintained a certain level of conditioning, muscle development, and muscle memory that would be necessary for further play. In *Homo*, running in play would have 'trained' the juvenile body and brain for adult running.

One of the most important elements of running as play was that running was a direct and *sensuous* way to develop an intimate familiarity with the landscape and its inhabitants. Bateson (2005) suggests that animals familiarize themselves with the environment during play, thereby decreasing the risk of later becoming prey. Activating the monoaminergic (dopamine and serotonin) system during play would have brought pleasurable responses to the participants while also facilitating cognition, social development, and survival-enhancing environmental awareness.

Running Deep: The Neurobiology of Endurance Running

Anecdotal narratives and some scholarly work suggest that prolonged periods of running generate the prolific 'runner's high', a 'euphoric sensation experienced during running, usually unexpected, in which the runner feels a heightened sense of well-being, enhanced appreciation of nature, and transcendence of barriers of time and space' (Pargman *et al.*, as cited in Dietrich and McDaniel 2004: 537). In more than a few runners, this experience includes spiritual feelings and even altered states of consciousness (Ackerman 2000; Dietrich 2003; Battista 2004; Cooper 2004; Dietrich and McDaniel 2004; Colmant 2005; Jones 2006). Due to the private and ephemeral nature of the experience, rigorous experimentation about the phenomena has been lacking. Athletic activities, such as rock climbing and surfing, have shaped popular perception that ties prolonged intense physical activity to psychological states of calm, transcendence, and heightened awareness. Publications such as Battista's *The Runner's High: Illumination and Ecstasy in Motion* (2004), a popular 'ethnographic' collection of runners' tales of their experience with runner's high, Ackerman's *Deep Play* (2000), Kotler's attempt to link surfing to neuroscience, *West of Jesus* (2006), and Cooper's *Playing in the Zone* (2004) create and reinforce a public construction of this emotive state.

A long-held view of 'runner's high' was based on the 'endorphin hypothesis', a direct consequence of alterations in endogenous opioid release due to induced exercise. Jones (2006, citing work done by Candau *et al.* 1998 and James and Doust 2000) characterizes the high as primarily the result of endorphin release (an endogenous opioid). The body releases endorphins during episodes of stress or pain. Upon release, endorphins bind to specific neural receptor sites (also the sites that exogenous opioids such as morphine bind), thereby blocking the release of neurotransmitters sending pain signals to the brain. There seems to be a time delay (perhaps as much as 30 minutes or more, depending on context, location, reason for exercise, and perhaps goal attainment) in endorphin release, which in recent studies has been related to blood pressure. This association of exercise with endorphin release has been suggested to produce feelings other than pain reduction, including euphoria and transcendence.

Studies on mammals, such as mice, rats, horses, non-human primates, and humans, have greatly increased our knowledge of the reward pathway and the inter-species genetic variability that results in individual reward experiences. This large body of work offers evidence of the interaction between neurochemicals in the reward pathway and the potential addictive properties of human running. Recent work has also established connections between monoamine release (serotonin and dopamine) and spiritual experiences (Winkelman 2000, this issue; Dietrich 2003; Dietrich and McDaniel 2004; Hamer 2004; Jones 2006; Winkelman and Baker 2008). Extreme states of activity or stress, such as endurance running, release endorphins, but also flood the brain with mood-enhancing and performance-enhancing serotonin and dopamine. However, some researchers indicate that perhaps the endorphin hypothesis may not account for all biochemical inconsistencies 'between the endorphin hypothesis and the physiological and biomechanical responses to endurance exercise' (Dietrich and McDaniel 2004: 536).

Work done on Fischer and Lewis rats (Werme *et al.*1999) has shed light on not only the reward system, but the varying levels of reward experience. Lewis rats are both addiction-prone and chronic runners. In lab tests, they ran longer than other rats given free access to running wheels, by engaging the same neural monoamine pathways in the brain as those engaged by morphine, cocaine, amphetamine, and so on. In effect, by running, the Lewis rat activated the same neurological circuits as those activated by drugs of abuse. The authors posit that chronic running and addictive drugs increase endorphins and 'modulate turnover' of central brain monoamines (where dopamine is suggested to be the mediator of a central reward mechanism) resulting in less aggressive behavior and less 'hyperexplorative' behavior when allowed to run. Forced withdrawal from running in Lewis rats leads to aggressive behavior that is similar to forced withdrawal from addictive drugs (Kanarek *et al.* 1998; Mathes and Kanarek 2006).

When looking at pain minimization in running, even low-intensity exercise has been found to activate the opioid system, but with different effects (Li *et al.* 2004; Bement and Sluka 2005). Interestingly, when horses were put through their paces on a treadmill, an additional source of opioid peptides was released into the circulatory system from the exercise-induced lysis of red blood cells during high- but not low-intensity running (Collinder *et al.* 2005). Over time, as exercise intensity increases, the number of opioid receptors on a cell's surface are reduced, therefore more running (hence activation) is needed to produce the same reward (Smith and Yancey 2003). Work by Koltyn and Umeda (2006) indicates that activation of the endogenous opioid system occurs when blood pressure is elevated during extended physical exercise, which in turn decreases the perception of pain.

It seems that dopamine is responsible for regulating the motivational aspect of the reward system (Rhodes, Gammie, and Garland 2005). When it comes to the reward (and motivation) system, dopamine stimulates certain brain regions, providing pleasurable effects. Other neurotransmitters such as serotonin and the endogenous opioids (Kelly and Berridge 2002) are also involved in this complex reward system by regulating dopamine release and act to promote a cumulative effect on the dopamine reward pathway.

Dietrich and McDaniel, testing both endurance runners and bicyclists on treadmills and stationary exercise bikes, found an appreciable increase of anandamide, one of the endocannabinoids, in blood plasma taken from the subjects (2004: 537). Endocannabinoids moderate or reduce pain sensations for both the peripheral and central nervous systems and produce similar psychoactive effects to THC, a constituent of marijuana. (THC binds to the same cellular receptor [CB1 receptor] as do endocannabinoids.) These effects include time distortion, enhanced euphoria, transcendence, reduced anxiety, and intense sensory perception, and for some, ‘touching’ the sacred or divine. Endocannabinoids, along with their exogenous counterpart, THC, enhance dopamine expression (Gardner 2005). Raichlen *et al.* (2008) corroborate the importance of endocannibinoids in the neural pathways engaged during running, and Raichlen himself has found in mice bred to run elevated amounts of endocannabinoids after exercise, compared to non-running mice.

Jones (2006) incorporates work by d’Aquila and Newberg (1998, 1999, 2000) to explain runner’s high as being an example of a ‘mystical (mythical) state of consciousness called Absolute Unitary Being (AUB)’ (2006: 39). Jones’s ethnographic work with ultra runners revealed descriptions of the high to include, ‘unitary connection, flow, boundless energy and cessation of time’ (2006: 41). It is the reoccurrence of the ‘profound experience’ of the high, Jones suggests, that promotes ultra runner’s impulse to run. D’Aquila and Newberg theorize that mystical states (and there is a gradient or continuum of such states in emotive experience) are the result of either the human sympathetic ergotropic system or parasympathetic trophotropic system reaching saturation levels during ‘hyperactivation’ and spilling over and activating the other system. The two systems include different functional parts of the brain, such as the hypothalamus, amygdala, and hippocampus.

Different kinds of movements activate each system. Meditation or slow, rhythmic movement activates the parasympathetic system and frenzied, excitable movement activates the sympathetic nervous system. Simultaneous activation and saturation produce ‘chance encounters’ such as ‘religious awe’ or glimpses of emptiness (2006: 42). Ratcheting up the experience to an AUB depends on achieving these maximal levels (chance encounters) repetitively and for longer durations, ‘progressively reaching more expanded states of consciousness through continual reinforcement of the practices’ (2006: 43). To Jones, ultra running, through the pounding of muscle and stress on metabolism and adrenal glands and the necessary slow, methodical, and rhythmic breathing and striding, not only saturates the two systems, but over the duration of the run, supersaturates the systems and the neural regions. Orientation, arousal, and vision cease to function properly, creating a pinnacle of experience through time loss, 'disintegration of self and complete state of peace or AUB' (2006: 44).

In all this research, what can be agreed upon is that endogenous neurochemicals, in the form of pain-inhibiting endorphins and a number of other neurotransmitters, are released during rhythmic and repetitive activities such as long-distance running. These same neurochemicals have an important role in play engagement and high-stress situations and have been documented to produce psychological and physiological states in rats, mice, and other mammals, including human and non-human primates. These states benefit performance, either through a reward system of seeking increased pleasure, euphoria, and so on, or allowing enhanced or extended performance. It may be the case that endorphins contribute to the overall reward system by partnering with an array of pleasure-inducing neurotransmitters, such as serotonin, dopamine, and/or endocannabinoids, blocking pain so the effects of those neurotransmitters that produce euphoria, transcendence, and so on, are more apparent.

The co-evolution of the pain and reward system with endurance running seems to represent an evolutionary strategy to ensure that running, as a critical behavior to *Homo* lifeways, was expressed, just as the perceptions of pleasure tied to eating and sexual activity (Rhodes, Gammie, and Garland 2005; Wise 2002). In a typical evolutionary unfolding, as happened with play, running hijacked the existing neural hardware and associated releases, and engineered the development of a Paleolithic runner's high. Neurochemical releases, documented in several studies utilizing rats, have produced behaviors that may have underlying behavioral correlates with humans. This suggests not only antiquity for the releases but similar neural pathways, and seems also to indicate that the origins for this reward system are far back in the phylogenetic history of mammals.

The Paleolithic Runner's High

In an expanding horizontal landscape, running became an essential movement pattern for subsistence, travel, and communication. In many activities, running episodes in *Homo* would have been over long distances. In terms of food acquisition, through scavenging, opportunistic hunting, and bouts of foraging, moving across the landscape would have necessitated intense periods of running, thereby selecting for efficient runners in human evolution. As the expanding savanna selected for those individuals most efficient at running, play forms such as locomotor and predatory play would have ontologically reinforced the running movement patterns and incorporated running-specific activity, echoing patterns seen in adults. The sheer intensity of running would have triggered the existing reward system, minimizing pain while producing sensations of euphoria and, for some, altered states. The neurochemicals and associated receptor sites within the brain would have already been a part of the neurobiology of early hominins, a legacy of mammalian evolution. The array of releases are many and the benefits to refining and fine tuning the neural circuitry of the release would have produced faster (in both endurance and sprinting speed), stronger, and more efficient runners.

The Paleolithic runner's high would have incorporated the intensity of the activity and the lurking danger of such a wide-open space, while the kinematic running platform would have generated the rush of release that would have matched the frequent incidence of function. The frequency of behavior in play can sensitize and modify neural structures, and perhaps rewire neural circuitry (Sivey 1998). Running would have been a frequent movement pattern in daily activity, thereby sensitizing and engaging the neural circuitry. Travel through and over the landscape would have produced an increased awareness of the environment and a trust of its provisioning capability. As Heinrich (2001) suggested, an 'allure' and pleasure of movement through the environment were included in the already functioning neural reward system.

Emergent Biophilia

Heinrich's suggestion of the development of a symbiotic relationship between the environment and the runner matches well with the development of a more advanced neural reward system providing interludes of experience as the runner moved through the horizontal landscape. Developing a strong and trusting relationship with the environment would have guaranteed learning and 'experiencing' techniques of processing sensory information concerning wildlife and plant life. Movement, especially intense running, would have generated emotive feelings similar to feelings of separation from ego and connection with a larger, more transcendent force that would have reinforced the need to become as knowledgeable about the workings of the ecosphere as possible.

E.O. Wilson (1984), later embellished with S. Kellert (Kellert and Wilson 1993), posited that humanity developed a *biophilia*, a natural affinity for the environment, a precursor of which can be seen in apes and other primates. This affinity is expressed in the deep appreciation of nature, where positive feelings towards certain habitats, activities, and objects in the environment are rooted in our biology and our genes (Wilson 1984, 1993; Kellert 1993, 2007). Wilson writes, 'these processes appear to be a part of the programs of the brain…marked by the quickness and decisiveness with which we learn particular things about certain kinds of plants and animals' (1984: 85). Wilson sees evidence of this tendency across existing cultures, where biophilia 'unfolds in predictable fantasies and responses from early childhood onward…[and] cascades into repetitive patterns across most or all societies' (1984: 85). Kellert sees this connection as a 'biologically-encoded tendency that emerged because over time it proved functional in the human evolutionary struggle to achieve fitness and survive' (2007: 26).

For most of human prehistory, humans and their ancestors lived as foragers, both scavenging and hunting and gathering *from* and *in* the environment, intimately involved with other organisms that populated that environment.[6] In every interaction between life and the environment, there was a sensuousness of nature, like the smell of decaying carrion or feces, the sound of the wind rustling over waves of grasses, the sight of the spotted coat of a quickly vanishing felid, or the blood of a wounded ungulate spattered in a pattern providing clues of direction and severity of wound. Such sensory perception could make the difference between eating a meal or becoming one. This sensuous relationship between organism and nature is also evidenced in chimpanzee behavior, featuring a primitive knowledge of plants with evidence of self-medication (Huffman and Wrangham 1996), the use of termite sticks (Goodall 1971, 1986), and the opportunistic and coordinated hunting of red colobus monkeys (Boesch 2003).

Wilson sees biophilia as an evolutionary adaptation where a 'certain genotype makes a behavioral response more likely, the response enhances survival and reproductive fitness, the genotype consequently spreads through the population, and the behavioral response grows more frequent' (1993: 33). These tendrils of biophilia are still wrapped in and around many cultures' belief systems. Wilson suggests a gene–culture evolution that would have played an important role in hardwiring biophilia into human biology through a genotype-directed behavioral response due to the selective value of 'knowing' your environment and

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[6] Hunting is not just a human behavior; evidence of opportunistic group hunting in chimpanzees has been observed (Stanford 1999, 2006). The onset of organized and collective hunting in human ancestors has been suggested to have occurred 400,000 years ago, perhaps even earlier. Certainly, long-distance running would have facilitated group hunting, although for this article, hunting would not have been the initial selection agent for running.

culturally represented in spiritual and religious narrative and myth due to human tendency to ‘translate emotional feelings into myriad dreams and narrative’ (1993: 33).

Running with the Gods

Perhaps the presence of endurance running in *Homo*, which is reflected in structure and suggested function, can shed light on *Homo* cosmology, a precursor to spirituality seen manifested in the Upper Paleolithic a million years further down the evolutionary path. Endurance running in *Homo* would have been a primary means to situate the runner, and, by proxy, those in the group, in the living environment. This would have facilitated selection for traits and behaviors specific to running encoded in the genes, as well as behaviors that emerge due to cultural traditions and influence of local environments, which are then translated into rituals. By running, the reward system would have produced strong emotive feelings to accompany the emerging biophilia, creating in its genesis a soliloquy of movement and ritual transcendence.

This association of reward with knowledge is suggested as the advent of awareness and can be thought of as the infancy of a Paleolithic ‘spirituality’, or as Berman (2000) describes, a ‘horizontal awareness’. In *Wandering God* (2000), Berman defines religion as the ‘sacred authority complex’ in terms of a vertical arrangement of spiritual and religious gods and other forces. Berman further speculates that the origins of religion began with the onset of a sedentary lifestyle associated with agriculture a mere 10,000 years ago.

In the last 100,000 years, human beings began to think of themselves as individuals separate from the natural environment. This cognitive alienation from nature brought into stark relief questions such as origins, mortality, qualitative differences between human and animal lifeways, and humanity’s ultimate place. Berman suggests the development of a ‘mode of consciousness’ similar to that found in recent forager societies and as we suggest representative of hominin evolution. Berman refers to this consciousness as *paradox* or *experience of space*, ‘diffuse or peripheral awareness…characterized as being horizontal by nature’ (Berman 2000: 3). Lacking the need to seek *meaning* in the natural intercourse of nature, or ‘hope that the world be this way or that way’ (2000: 3), there is an acceptance of the world as is and an inferred high level of trust in the machinations of nature. The ego/nature equation is not solved, as the dichotomy seems to be implicit in the modern human approach, but accepted as part of the ongoing beat of existence in a world where the individual and group are part of a larger dynamic environmental calculus. In this paradox, early humans submerged the conflict of ego apart from nature by dispersing the 'tension' horizontally through the trust in the environmental 'present'.

As populations increased and agricultural practices were adopted, humanity settled down and tore the fabric of this calculus. Existential harmony based on a horizontal 'trust' went vertical, and the syncopation of nature's beat was exemplified by the more prominent place death assumed in the culture, and the reliance on gods and spirits that resided high above the ecological uncertainty resolving the inherent conflicts of ego's mortality. We suggest that endurance running sustained horizontal consciousness as well as fulfilled other needs of evolving *Homo*. Looking at running in Native American past and present lifeways, the symbiotic relationship between ego and nature is played out in cosmology and ritual. Running served many purposes in ancient Native American cultures as well as the contemporary lifeways of Tarahumara and Nandi. Races and gaming were popular parts of the fabric of Indian ceremony and celebration. Nabokov's *Indian Running* (1981) describes the depth to which running was incorporated in their spirituality. He says, 'Gods and animals ran long before Indian men and women ever did. Thereafter, the gods told people to do it and the animals showed them how' (Nabokov 1981: 23). Oral histories of most, if not all, tribes contained folk 'narratives' that featured mythical races ordering the world and providing a powerful model and 'mandate' for Indian lives. Racing contests among the gods and spirits determined 'temperaments' and physical characteristics of the first animal inhabitants, later ancestors to Indian warriors and peoples, and staked first claims to territories.

Origin myths of the Cheyenne feature races which separated human from animal. Nabokov details other Indian tribes whose mythology is replete with running and races. For example, Yokuts believe the Sacramento River was formed by a runner moving inland, the river evolving in his wake. The Navajo best exemplify the intimate relationship between running and a primordial motion, 'inventing vehicles of speed and efficient transfer' (Astrov in Nabakov 1981: 27). Running and racing follows oral histories from generation to generation, emphasizing running as a conduit 'between worlds…a way of communicating with timeless spirits and powers' (Astrov in Nabakov 1981: 29). The runner in celebration and in ceremonial runs, perhaps, races to engage in competition and health, or even enact a ritual such as a run for rain. However, according to Nabokov, the runner, through a deeper transformation independent of the present or the landscape, becomes the message.

Running Spirituality

There seems to be a consensus among most researchers that religion, complete with institutions, mythology, roles for religious specialists, and so on, evolved late in humans; the evidence involves the appearance of cultural materials, including advanced tool technology, that signify the development of symbolization, including personal ornamentation and rock art (Dickson 1990; Mithen 1996; Lewis-Williams 2002). Boyer's (2002) account is perhaps the simplest, yet most powerful, in its acceptance of religion as a cognitive mechanism to maintain an ever increasing complexity of social interactions and social integrity. Dawkins (2006) and others (e.g. Atran 2002) characterize Boyer's theory as one in which religion is a 'by-product of normal psychological dispositions' (Dawkins 2006: 177). In Boyer's theory, religious concepts engage existing mental systems that are activated by the normal intercourse of life. Therefore, the underlying patterns of religious concepts are motivated by the structure and operation of the brain, where social knowledge as well as the instructions for operating in a complex social environment are stored.

Even the cognitive science approach (as represented by Boyer, Barrett, Atran, Dawkins, and increasing numbers of others), describing religion as a by-product,[7] insinuates a 'soft' threshold of minimal neural components, connections, and wiring necessary for religion and the oral transmission of metanarratives, myths, and folklore. As the above discussion holds true for modern *Homo sapiens*, speculation on religion as a system of beliefs for earlier *sapiens*, even *erectus*, is not supported. Evidence that would support religion further back in time, such as material artifacts reflecting symbolism, has not been found.

When turning our gaze on human ancestors, as we search for the spark of belief in an otherwise dim world, the need to find some type of material artifact to support a belief system in early *Homo* reflects the current *sapiens*-centric view of spirituality and religion. Where researchers hypothesize that earlier belief systems were similar to present-day systems, they expect to find more than simple stone tools in the archaeological record. Here we look instead to traits and behaviors that remain with us today as indications of a much deeper antiquity of behaviors that we have labeled as 'spiritual'.[8] These 'legacy' traits would have persisted

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[7] See Sands's Introduction to this issue for a more detailed review of contemporary theory in natural origins of religion.

[8] King (2007) and Winkelman (this issue) posit an antiquity of at least precursors of religious behaviors in chimpanzees, suggesting a predisposition that extends back in time to very early hominin evolution.

over time because they provided some type of advantage to individual and group survival. Passed to each successive generation, these traits would have been genetically 'hardwired' and still linger in humans today. A runner's high and the sense of a kinaesthetic–nature biophilia are just those legacy traits that indeed resurface in ultra runners and through other intense and prolonged physical exercises.

It is suggested here that the development of running, specifically endurance running in response to an expanding horizontal environment in East Africa, was a critical behavior that acted to facilitate selective advantages as *Homo* adapted first to the fluctuating African paleoenvironment, then later to predominantly savanna and other environments outside of Africa. Besides providing a mechanism to optimize scavenging opportunities as well as opportunistic hunting and extended foraging, running provided effective transport and a means for long-distance communication, while also allowing for greater exploration of the landscape, providing novel situations for increased mental and physical stimulation.

With *Homo erectus*, an exodus occurred from the tropical and subtropical climates of Africa into the more temperate and seasonal regions of the Northern Hemisphere such as Eurasia and the Far East. Success of the species for over one million years indicates an intelligence that is more than adept at the process of social learning and the necessary development and transmission of cultural traditions (Richerson and Boyd 2000). These migrating groups of *Homo* were foragers, a lifestyle that required movement and flexibility to adapt to differing environments. In these novel environments, running would have been instrumental in moving through the foreign landscape.

Berman's 'horizontal awareness' in part describes the experiential world the first runners would have engaged. Crucial to this engagement of *paradox* is the experience of neurochemical releases that acted to reduce or minimize pain from the actual physical exertion of running and the engagement of a reward system that provided an enhanced sense of connectivity to the environment. This would have been a kinetic experience, where movement would have provided the entrance into and continued participation in this state of 'immanence', a state of heightened reality made possible by the flush of neuroresponses, so that the details, no matter the significance, seemed to 'blaze' to the runners. As running was frequent, the kinetic experience of running would have yielded to repetitive occurrences of the 'high' and the continual sensitization of the reward system. This would have been the Paleolithic runner's high, where the ritual of movement was interwoven with the necessity of survival. It is not, to Berman, a 'sacred' experience, but an experience that has no parallel in most contemporary human cultures. As he says, 'in this world the secular *is* the sacred' (Berman 2000: 11). In essence, running long distances (endurance/ultramarathoning to an extreme), 'experienced' through our neurobiology (runner's high) and ritualized into a running 'spirituality', is a legacy of the role running played in the evolution of our species.

Conclusion and Further Reflections

Endurance running in hominid evolution can be seen in skeletal manifestations that appear in *Homo erectus*, visible in the KNM-WT-15000 specimen. Paleoenvironmental and paleoclimate reconstructions, archaeological evidence of quantity and disposition of faunal remains, and ethnographic accounts that would implicate endurance running as a movement pattern tied directly to scavenging or hunting has engendered recent debate (Lieberman *et al.* 2007; Pickering and Bunn 2007). The question of 'use', however, does not overshadow the biomechanical evidence of *Homo* being quite capable of endurance running. The suggestion advanced here is that endurance running generates neurochemical releases that stimulate the existing reward system. This has been shown in studies on mammals, including humans in moderate to intense physical activity, as well as during situations of high stress and play episodes. There is further evidence of exogenous drugs binding to the same receptor sites as endogenous neurotransmitters, producing similar physiological and psychological experiences in the reward system as those tied to endurance running.

Since running would have been tied to scavenging and hunting, evidence in the form of increased paleontological remains of either scavenged or hunted animals would support the importance of running in *Homo* subsistence. As it turns out, analysis of several sites offers support along these lines. Additional support for the hypothesis of the runner's high activating the reward system can be found in comparative analysis of neural releases in a variety of 'habitual endurance runners', such as canids and horses, and a comparison with apes. Studies on rats have already produced an adequate model of the release system, suggesting that similar systems would be found in other mammalian long-distance runners.

Much work has been done toward understanding the culture of *Homo erectus*. A survey of studies presents important facets of daily existence, mostly tied to subsistence and social relations.[9] Due to a paucity of ‘symbolic’ material, there seems to be a dearth of work that discusses or advances observations or thoughts on play, adult recreation and leisure, and ritual in early and middle Pleistocene *Homo*. *Erectus* tool traditions show a gradual increase in complexity for the length of time that *erectus* was the dominant hominin species,[10] yet generally advance a picture of little cultural innovation or creativity. That *erectus* was a global traveler, locally adapting over time and space to the last million years of ice-age-induced climate change, indicates a species that was ‘in tune’ with their surrounding ecology.

This leads to the central contention of this paper: *Homo* had developed in concert with the development of endurance running and the associated reward system, a ‘horizontal awareness’ based on a biologically based, culturally reinforced ‘biophilia’, that would have been enhanced through the reward system. This awareness, or *Paleolithic high*, perhaps dissimilar to *sapien*s’ spirituality that developed only in the last half of the Upper Paleolithic, provided *Homo* with a means to reinforce the necessity of running for survival and situate individual genus members as part of a larger and dynamic environment. This intimate environmental bond was facilitated and communicated through running. To borrow on a contemporary evolutionary psychology assessment, humans are wired, both in body and mind, to be runners; however, the ultra running movement today is only a pale reflection of what would have been an essential and reflective part of *erectus* lifeways.

While our culture has eliminated the need to run, the legacy traits of our ancestors have not disappeared. Contemporary diseases such as diabetes and chronic high blood pressure, along with a diet that has little resemblance to the dietary intake of our foraging ancestors (Eaton, Konner, and Shostak 1988; Eaton, Eaton III, and Konner 1997; Cordain 2006), provide reminders of that legacy. The runner’s high experienced today also reflects this legacy; however, one can only consider the effect

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[9] See work on ecology (Kramer 2004), dispersal rates out of Africa (Anton, Leonard, and Robertson 2002), energetics (Gruss and Schmitt 2004), social learning and intelligence (Robson and Kaplan 2003), gender roles, reproduction, and foraging (Vitzhum 1997; O’Connell, Hawkes, and Blurton Jones 1999; Aiello and Key 2002), diet (Milton 1999; Ungar *et al.* 2006; Cordain 2006), extant ethnographic analogies of hunting to foraging (Marshall 1976; Shostak 1976; Hilton and Greaves 2004; Draper 1997; Liebenberg 2006), and conceptual abilities inferred from tool making (Wynn 1992; Plummer 2004).

[10] Late *erectus* from sites such as Zhou Kou Dien and Terra Amata exhibit or infer cooperative hunting, fire, and in some cases artificially constructed shelters, and advance a more relatively complex social and cultural organization.

of that experience on modern-day populations that lived and ran on the terrain of the past.

A possible avenue to further research would be ethnographic work among the Tarahumara, possibly the last known living culture that runs to live, work, and play.[11] Although Lieberman *et al.* (2007) suggests, some of the failings of ethnography as it has been applied to extinct hominins, we believe that ethnography of running cultures, especially in terms of ritual, spirituality, and running as an environmental interface, could generate useful data to reflect back on the nature and role of running in human evolution. If the supposition that humans are wired to run is correct, identifying these features in cultures that still feature running as behavior integrated in cultural lifeways would be beneficial to at least understanding some of the ways in which running has been critical for *Homo*. Perhaps, ultra runners and running cultures such as the Tarahumara and the Nandi hold a tenuous bridge to humans' ancient running past and spiritual traditions and the beginning of humanity's complex relationship with nature.

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[11] It would also be interesting to examine modern Kenyans and Ethiopians who have substituted running for money in professional road races for their traditional reliance on running for subsistence.

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