

Non-Human Origins of Human Perception in the Pre-Pleistocene

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In this essay we argue that the human perceptual and sensory mechanisms, which have been described as part of the emergence of our species during the Pleistocene, are part of a much earlier evolutionary trend. Evidence for the pre-human development of our perceptual systems is explored using the comparative literature of non-primates and non-mammals. Furthermore, we argue that evolutionary psychology theorists have tended to misconstrue the mechanisms of perception through an anthropocentric lens. Other lines of thought contend that much of hominid cognition and perception is evolutionarily unique to the point that a broad cognitive discontinuity exists between humans and other species. While the emergence of our species during the Pleistocene clearly has a significant influence on the human brain and mind, it is our contention that perception, and, arguably, the basis of most cognition, is related to much more longstanding environmental constraints as they impacted biological development. Comparative evidence from primates, other mammals, and non-mammalian species, in addition to an evaluation of evolutionary forces and history, are used in support of this argument. The human mind seems to be ancient in its architecture having been sculpted by longstanding and pre-human ecological constraints originating in perceptual mechanisms that significantly pre-date the Pleistocene.

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Evolutionary psychology has been used to promote hypotheses for several critical mechanisms in the development of perception–action links (e.g., Cosmides and Tooby, 2013; McBurney, Gaulin, Devineni, and Adams 1997; New, Cosmides, and Tooby, 2007; Tooby and Devore, 1987). Frequently these hypotheses emphasize

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evolutionary forces that shaped the dawn of humanity during the Pleistocene epoch (approximately two million to 11,000 years ago). As humans became a species and entered the cognitive niche (Tooby and Devore, 1987), the environment and necessities of day-to-day life required a certain set of perceptual and cognitive abilities to enable survival and sustainability. Modern humans seem to have developed a cognitively unique genus with the advent of symbolic and linguistic systems (Penn, Holyoak, and Povinelli, 2008a, 2008b). Moreover, some perspectives have emerged from cognitive archeology and philosophical anthropology which suggest that the cognitive evolution in hominins is based on an emphasis in sociality (Sterelny, 2007), and subsequently the emergence of language and tool use in modern humans (e.g., Garofoli, 2015; Huffman, 1986; Ingold, 1996; Penn, Holyoak, and Povinelli, 2008a, 2008b).

As Penn and colleagues have argued, there is a discontinuity between human cognition and the rest of the animal kingdom (Penn, Holyoak, and Povinelli, 2008a, 2008b). While it is important to consider the evolutionary pressures during the Pleistocene that directly influenced human cognitive developments, one can speculate that substantial portions of the cognitive architecture, and our human “program,” had evolved in the pre-Pleistocene (before humans emerged as a species). In particular, cognition would have been shaped in response to the perceptual systems and the information that those systems afford. Hence, it may be important to review some of the Pleistocene-based mechanisms that have been proposed and to consider what pre-human perceptual architecture and evolutionary forces may have shaped human cognition (e.g., Shaw and Kinsella-Shaw, 2012; Swenson and Turvey, 1991; Turvey and Carello, 2012). With respect to this review, we will revisit some of the specific challenges of using Pleistocene vs. pre-Pleistocene models that have been proposed (e.g., Heyes, 2012; Panksepp and Panksepp, 2000; Sterelny, 2007). Further analysis will investigate particular examples in perception–action cycles as well as the cognitive systems supporting these processes. These examples will be referenced with specific regard to how perception–action cycles may have formed from a thermodynamic perspective (Swenson and Turvey, 1991). Finally, some conclusions will be considered that reflect this extended view of adaptive mechanisms and how that might shape our understanding of human perception and behaviors.

In this essay we will specifically address the perceptual mechanisms posited by evolutionary psychologists to exist within the human cognitive representation system and we will examine evidence that is, perhaps, indicative of other species harboring such perceptual mechanisms. Each of these examples of perceptual mechanisms has been speculated as part of human evolutionary history and adaptation. However, using the tools of cross-species comparison and phylogenetic records, we believe that much of these “human” adaptations can be better understood as part of more general mammalian and pre-mammalian evolutionary trends. As we trace through this evidence we will clarify some of the problems associated with using

an anthropocentric approach. Finally we will review some of the pressing issues and caveats of these theories.

Early Perceptual Mechanisms

The detection of motion for the use of finding food sources and avoiding danger has been a long-standing requirement for most species. There are a number of mechanisms evident in humans that would seem to demonstrate our link to pre-mammalian (and pre-Pleistocene) developments. Among these should be considered Reichardt detectors (Lu and Sperling, 1995; Van Santen and Sperling, 1985); collary discharge for motion perception (e.g., McCloskey, 1981; Stark and Bridgeman, 1983; Yasui and Young, 1975); and the use of tau for optic flow and collision detection (Beardsley, Sikoglu, Hecht, and Vaina, 2011; Lee, 1998; Loomis and Beall, 1998). The importance of these mechanisms is that each offers an effective and necessary solution for determining how our bodies move through space, and anticipating safe and effective behavioral responses.

Reichardt detectors, for example, were originally studied in flies (Reichardt and Poggio, 1979), and are evident in insects, reptiles, and humans (Van Santen and Sperling 1984, 1985) to detect motion across a receptive field. These low-level motion detectors use a relatively simple and mechanistic approach to the detection of moving objects. Receptive fields within the eye are compared using the coincidence of their stimulation at a common neuron. When a set of receptive fields representing two positions on the retina are stimulated, then, based on their relative alignment, spacing, and orientation, they may produce concurrent stimulation at the neuron — thus resulting an indication of motion. To stimulate these patches, motion must occur at a very particular trajectory relative to the position of the eye and failing to do so will potentially stimulate one, but not both receptive areas. Consequently, no indication of motion would occur for that detector. By employing a number of Reichardt detectors to represent the gamut of advantageous trajectories, these simple mechanisms can provide a complete range of sensitivities to different velocities and orientations of motion. Motion detection of this sort is important for safety and successful behavior. The cross-species evidence with insects and other non-mammalian species suggests an ancient development of this mechanism, but one that is now evident in humans.

An example of a more sophisticated form of motion detection is the sensitivity to optical rates of expansion in the form of tau. Tau has been suggested as a principle mechanism for diving Gannett's (birds) and mammals to determine self-direction and a range of time-to-arrival estimations within optic flow fields (e.g., Lee and Reddish, 1981; Tresilian, 1991; Warren, 1995). As described with Reichardt detectors, the sensitivity to optic flow has been critical for addressing the perceptual challenges of self-motion detection and collision detection; suggesting a common origin of this mechanism such that it is now shared across multiple

mammalian and non-mammalian species. While tau is a direct function of the inverse square law in optics and acoustics, the processing mechanisms for those ecological constraints were necessarily more complicated than Reichardt detectors. With tau, sensitivity to expansion and local deformations of optical patterns became critical for tracking motion (Koenderink, 1985), and thus a more specific type of pattern sensitivity was required by those biological systems that made use of them.

The use of mechanisms to detect corollary discharge further contributes to the perception of optic flow, in as much as one must account for personal body movements of the eyes, head, and neck to appropriately account for personal versus global changes in the environment. Consequently, with an account of corollary discharge, and sensitivity to changes over time with local and global tau, the optic flow field is populated with a reliable indication of critical self-motion information. As an initial set of examples, it is clear that with motion perception many of the mechanisms employed within human perception represent long-standing evolutionary problems. The architecture to solve those problems was necessary prior to our species' emergence — hence the evidence of these mechanisms in the much earlier developed avian and insect species. While it may be easy to find examples of these kinds of mechanisms with relatively complex, but seemingly low-level problems like motion, we would further argue that higher-level cognitive-perceptual mechanisms also represent pre-human, and often pre-mammalian, adaptations.

As one considers the early development of motion sensitivity, these mechanisms may be seen to be related to more general principles of the environment, including physical ecological constraints (e.g., Swenson and Turvey, 1991). Swenson and Turvey have postulated a direct connection of perception-action cycles with thermodynamic principles. In this framework, entropy production and energy conversion from food sources are the primary selective forces for motion and motion perception. By extension, one could formulate that the early perceptual mechanisms for motion may have evolved in response to an organism's consumption and conversion of energy resources. These early motion-based mechanisms would seem to provide a critical means of entropy production across and between biological systems. The capture and digestion of one species serves the continued entropy of the ecology. Over evolutionary time and with progression toward complexity, organisms have increased in perceptual sophistication towards efficient entropy production. Simply put, the thermodynamic systems approach encapsulates evolution within a pre-Pleistocene (and pre-biological) framework predicated on fundamental, physical properties of the universe. Among content-specific traits that potentially indicate a higher-level of perceptual processing, one might include the incredible human proficiency for the visual recognition of faces. Our sensitivity to both configural and feature-level aspects of faces, and the recruitment of specialized neural processing in the fusiform gyrus, suggest the high cognitive demand and capacity with this function, and perhaps even a modular development

for its detection (see Bruce and Young, 2012; for a review see also Puce, Allison, and McCarthy 1999). Our demonstrated and specific sensitivity to human faces, despite a normative insensitivity to facial differentiation of non-humans, is a clear indication of a human-specific perceptual demand.

Despite this human-specific function, there is also very clear evidence that the mechanisms for facial processing are not human-specific (e.g., Pascalis and Bachevalier, 1998; Tarr and Gauthier, 2000). Comparative research with *Macaca mulatta* monkeys shows their preferential attention to monkey over human faces (Pascalis and Bachevalier, 1998); and both chimpanzees and monkeys have been found to use neural mechanisms that are analogous to those employed by humans for face detection (e.g., Eifuku, De Souza, Tamura, Nishijo, and Ono, 2004; Parr, Hecht, Barks, Preuss, and Votaw, 2009; but see Perrett et al., 1988). Chickens have also been found to be responsive to face stimuli in recognizing con-specifics (Rosa-Salva, Farroni, Regolin, Vallortigara, and Johnson, 2011; Rosa-Salva, Regolin, and Vallortigara, 2010, 2012). Consequently, it seems that with facial recognition among conspecifics, our high-level sensitivity to face information is not specifically a human-based cognitive trait. Certainly face perception is critical, and the capacity to adapt somewhat unique processing to support our expertise with this ability is apparent in humans. With respect to this review, however, we merely highlight that our expertise for faces seems to reflect the evolutionary turn of a human-specific modification of an already effective and critical perceptual strategy that is well-evident across several species.

Cognitive Maps, Representation, and Wayfinding

Evidence of higher-level cognitive-perceptual functions have also been identified in spatial mapping and processes (Krasnow et al., 2011; McBurney, Gaulin, Devineni, and Adams., 1997; New, Krasnow, Truxaw, and Gaulin, 2007). It appears that females have a spatial gathering advantage over males, and that this capacity represents the use of cognitive mapping and allocentric environmental representations. Presumably our sexual dimorphism of cognitive mapping may have evolved in ancestral humans because of sex-based social roles in hunting and gathering. This would potentially reflect a human disconnect as an extension of the unique sociality of our species (e.g., Sterelny, 2007). The habitual involvement in gathering by females, and hunting by males, is hypothesized to have supported a sexual dimorphism in spatial processing: humans encode the locations of higher-quality resources more efficiently than lower-quality resources (New, Krasnow et al., 2007). This gathering navigation theory has also been used to predict the formation of a highly accurate and landmark-based environmental representation by women in order to encode the location of food in familiar environments (New, Cosmides, and Tooby, 2007). In contrast, males are theorized to harbor an advantage in encoding more general, and non-landmark specific, spatial awareness for hunting animal prey

in unfamiliar environments (James and Kimura, 1997; Krasnow et al., 2011; New, Krasnow et al., 2007). While socio-cultural adaptations in humans would seem to have produced this sexual dimorphism, New, Krasnow et al. point out that sexual dimorphic foraging is not human-specific. With respect to other primates, there has been a recorded male bias in chimpanzees even though hunting provides only a small percentage of the chimpanzee food source (Stanford, Wallis, Matama, and Goodall, 1994). Consequently, the sexual dimorphism in spatial memory and representation is a product of human evolution, and one that continues to be evident in current spatial attention and memory tasks (Krasnow et al., 2011). However, evidence suggests that (a) there may have been less cultural/functional sexual dimorphism among humans than previously speculated (e.g., Fuentes, 2012) and (b) that, again, the neural dimorphism of spatial processing between the sexes may pre-date human evolution (Jacobs, Gaulin, Sherry, and Hoffman, 1990).

Of course, sexual dimorphism at a variety of levels is found across mammalian and reptilian sub-species and this neural dimorphism in spatial memory may reflect much more basic and phylogenetically early adaptation. Moreover, the marked differences in male and female hippocampus for spatial processing tends to emerge at four years of age (with girls outperforming boys on various spatial tasks). At age five boys slightly outperform girls; and at age 11, boys significantly outperform girls in spatial testing (Linn and Petersen, 1985). Taken together, these findings may be used to suggest that, whatever the level of dimorphism, it may become exaggerated with an individual's experience; it does not necessarily reflect a specific evolutionary mechanism; and does not appear to indicate an anthropocentric adaptation. Sexual dimorphism in spatial ability has been documented in a range of mammals. Meadow voles were tested in a variety of mazes and a sexual dimorphism in spatial abilities was revealed wherein males outperformed females (Gaulin and Fitzgerald, 1986, 1989; Kavaliers, Ossenkopp, Galea, and Kolb, 1998). Rats have been tested on a variety of mazes and have demonstrated a similar dimorphism favoring males in spatial ability (Cimadevilla et al., 1999; Dawson, 1972; Eison, 1980; Joseph, Hess, and Birecree, 1978; Seymoure, Dou, and Juraska, 1996). Primate testing with Rhesus monkeys has also shown a sexual dimorphism in spatial ability favoring males (Lacreuse, Herndon, Killiany, Rosene, and Moss, 1999). These findings suggest that sexual dimorphism in spatial cognition exists in other mammals and may be indicative of an earlier evolved sexually dimorphic spatial cognition phenotype in hominins.

These evolutionary branch-offs in mammalian spatial evolution are evidence that a common ancestor in mammalian evolution, and more importantly the human lineage, had a sexually dimorphic perceptual precursor to human spatial cognition. Hence, both the kind of dimorphism and the nature of our spatial cognition appear to be a part of a broader evolutionary trend for wayfinding. Males outperforming females across species is not always the case; there appears to be some ecological constraints at work as female cowbirds have been found to have

more accurate spatial representation than males (Guigueno, Snow, MacDougall-Shackleton, and Sherry, 2014). Inasmuch as our cognitive mechanisms derive from our representation and navigation through space, one might further surmise that sex-based differences in spatial cognition represent pre-Pleistocene evolution.

Sex-based differences in perceptual processing occur in many animal clades, however, human spatial representation is unique in that we all possess the cognitive architecture to perceptually capture the environment through the use of geographical maps (Wang and Spelke, 2002). Although the cognitive architecture of humans seems to be among the most sophisticated of all animals, a diverse range of animals from mammals to insects have perceptual and cognitive capabilities that allow for complex navigational skills including those required for efficient foraging and nesting. Wang and Spelke (2002) have noted three distinctive systems that are present in a wide range of animal clades: (1) a path integration system that constantly updates location relative to the environment; (2) a place recognition system that uses template-matching of environmental landmarks; and (3) a re-orientation system that complements the path integration system when it has been disrupted. Of particular interest is that the studies of these key systems suggest that the primary means of efficient foraging and nesting are manifested in a large variety of animals and are hardly restricted to humans, despite a reliance on higher-order spatial processing and representation. Various animal clades including humans are known to rely on geometric patterns to determine their place in space and to categorize new visual stimuli (Rosa-Salva, Sovrano, and Vallortigara, 2014; Tommasi, Chiandetti, Pecchia, Sovrano, and Vallortigara, 2012). Hence, it may be plausible that a spatial gathering mechanism has an earlier phylogenetic origin and one that is non-specific to human evolution.

As noted above, the gathering navigation theory of spatial navigation is that animals preferentially encode the locations of higher-quality energy resources over lower-quality energy resources. Gathering navigation theory is a form of spatial navigation that is also consistent with the notion of efficient entropy production (e.g., Swenson and Turvey, 1991). As per theory and the Swenson and Turvey framework, gathering may be fundamentally guided and shaped by the environment to promote an organism's ability to find higher-quality energy resources. Individual success, as posited in gathering navigation theory, allows for thermodynamic efficiency in that it serves biological and physical environmental demands.

Shared Mechanisms for Cognitive Representations of the World

The seemingly high-level mechanisms that may be mistaken as having developed during the Pleistocene may be a part of a longer evolutionary trend. Cosmides and Tooby (2013) have argued that “Evolutionary psychologists emphasize hunter-gatherer life because it takes a long time for natural selection to build a computational adaptation of any complexity” (p. 203). To clarify one of these mechanisms

in humans one can consider the category-specific attentional allotment (e.g., New, Cosmides et al., 2007). In fact, New, Cosmides et al. posited that "...the *human* attention system evolved to reliably detect certain category-specific selection criteria" (2007, p. 16598). It is interesting to consider this claim for it suggests what could be construed as a bias in the field. Namely, that higher-level perceptual knowledge evolved out of a period of *human*-specific changes, rather than an earlier mammalian or pre-mammalian mechanism for detection of this category-specific information. Even tacitly excepting from this statement that there is a basis in the biology with deeper phylogenetic origins, the function is described as functionally human. With respect to this example, category-specific visual attention is understood as a sensitization and capacity to separate animals (both humans and non-human) from a complex visual background. This capacity improves reaction times for detecting a category-specific change in animate objects (humans and non-human animals) within a visual landscape relative to inanimate objects. This category-specific attention to biological objects is thought to support improved performance encoding environments and potentially salient aspects therein. We reiterate that New and his colleagues concluded that this is a critical human visual-attention mechanism and one that supports our expertise using biological motion and categorization. Consequently, these suppositions are consistent with the animate monitoring hypothesis (New, Cosmides et al., 2007): whereby animate objects are consequential time-sensitive elements in a visual scene. In contrast, inanimate features of the environment (plants, rocks, etc.) are less time-sensitive but are vital categories to the human perceiver. While it may be that the human propensity to detect an animate object, such as a predator or prey, over an inanimate object was refined during the Pleistocene, one can speculate that category-specific visual attention to animate objects has deeper ancestral roots. It is this possibility that we can explore by examining parallel abilities in non-human species.

Sensitivity to detecting animate objects over inanimate objects in the visual environment was essential to the survival of humans (New, Cosmides et al. 2007). Moreover, it is crucial to the survival of any animal species that it can be potential prey, or that it has a requirement to catch prey, and thus to be sensitive to biological motion. Infants have a moderately well-developed visual system and can visually attend to objects, people, and events readily over inanimate stimuli in the visual environment; they are prepared to process sensory information about motion and integrate time and space from the very onset of their lives (Frankenhuis, Barrett, and Johnson, 2012). This suggests that sensitivity to biological motion may be an innate capacity in humans. One might further argue that there is a perceptual mechanism for sensitivity to biological motion in humans, and, consequently, that like many human psychological capacities, this adaptation emerged during the Pleistocene. However, it is plausible that sensitivity to biological motion has an earlier phylogenetic origin.

Evidence shows that a variety of non-human animal species have sensitivity to biological motion (self-propelled motion) over inanimate motion. This has been

demonstrated in non-human primates, namely baboons (Parron, Deruelle, and Fagot, 2007). It is also striking to find that a similar innate ability has been found in newly hatched chicks (Mascalzoni, Regolin, and Vallortigara, 2010). That advantage and whatever common phylogeny we share with avians would seem to have allowed for, and likely supported, the development of biological motion sensitivity in the pre-Pleistocene.

With respect to biological sensitivity, chimpanzees (e.g., Vonk, Jett, and Mosteller, 2012) distinguish natural categories and form concepts of the environment. These categories would necessarily reflect the social-cognitive requirements of the chimpanzee community, as a means of expressing appetitive and aversive — potentially dangerous stimuli — for the social group (Sterelny, 2007). Hence, these higher level perceptual representations could potentially have contributed to the cognitive disconnect between humans and other mammals. However, non-mammals, such as pigeons, demonstrate a capacity for the categorization of animate/inanimate objects but do not form concepts regarding whether a categorized object is a predator or innocuous (see Fersen and Lea, 1990). Among hominids, it has been found that chimpanzees can discriminate natural categories in the same manner as humans using category-specific knowledge of animate objects (Vonk, Jett, Mosteller, and Galvan, 2013). In addition, the chimpanzees were found to be able to distinguish between animal and non-animal objects on a computer screen. This finding would seem to be indicative of a parallel ability in chimps to humans, and thus may represent that biological category distinction evolved at an earlier period in evolution. Vonk et al. (2013) have further noted that studies have shown a more general ability among primates for recognition of biological objects. Also, the phylogenetically distant mammal, the black bear, has been found to distinguish between natural categories and to form concepts of animal types (Vonk, Jett, and Mosteller, 2012). Hence, while there may be social constraints on category perception and knowledge formation (e.g., Sterelny, 2007), the capacity for this ability does not seem specific to hominids. In fact, as noted by the researchers, black bears were found to be able to learn category-specific knowledge in a shorter period of development than were great apes (Vonk et al., 2012, 2013).

Hence, it is plausible to theorize that the perceptual mechanism of category-specific visual attention to animate objects in humans is not a Pleistocene-based adaptation. The finding that we may share these fairly high-level and abstract perceptual and cognitive abilities for category-specific judgments with other mammals may indicate that humans, and perhaps even our closest relatives on the phylogenetic tree (e.g., ancestral hominids and apes, monkeys and pro-simians — most of which have not been studied for this adaptation), may share a pre-Pleistocene common ancestor with the perceptual and cognitive precursors to our current evolved perceptual phenotype. It may be important to repeat there is some tacit acceptance of that earlier evolutionary history, and yet a persistent bias to describe the traits as grounded within the Pleistocene. Given the evidence supporting an earlier

evolutionary history, that bias to use the Pleistocene, and the dawn of humanity, in theorization of mechanisms is potentially misleading and inconsistent with the necessity for a consideration of more longstanding ecological constraints.

Social primates have been found to actively follow the visual gaze of conspecifics as they apprehend their environment to look for food and watch out for predators (Tomasello, Call, and Hare, 1998; Tomasello, Hare, and Fogleman, 2001). It is of adaptive significance for social primates to follow social cues that warn conspecifics of potential food or predators (McNelis and Boatright–Horowitz, 1998). Social cues, such as this example with visual gaze, may not be of the same significance to modern humans as they were to ancestral hunter–gatherers. No longer are most modern humans required to forage, hunt, or be vigilant for predators as would have been required of our Pleistocene ancestors. Nevertheless, humans have certain behaviors that other primates possess and we also share perceptual and cognitive mechanisms that are derived from shared ecological demands (Haun, Jordan, Vallortigara, and Clayton, 2010; Lauder, 1994).

Human Cognition in the Pleistocene

“Modification and perhaps specialization of the digestive tract and dentition to take advantage of these new food sources provides an explanation for the hominid radiation that took place two to three million years ago separating hominids into several different ‘specialists’”(Tooby and DeVore, 1987, p. 212). This intermediate hominid adaptive specialization would have ended when one diverging branch advanced far enough into the cognitive niche that its general solution to local adaptive problems proved superior to the specialists.

Tooby and DeVore (1987) have argued that the Pleistocene era has been most critical to the development of human cognition. It is, in fact, undeniable that the later development of the neocortex has supported a dramatic change in the complexity and capacity for cognitive and meta-cognitive abilities (see Marino, 2000). It is also evident that this more recent adaptation of the brain during the Pleistocene is fundamental to modern human cognition. Hence, while it is important to accept and embrace the more recent changes in cognition during the Pleistocene, there are also some foundational reasons to speculate that perception and actions may have evolved as part of an evolutionary trend that significantly predates the Pleistocene. Whether we consider *Australopithecines* (4 million years), the *Ardipithecines* (5.5 million years), stretching back almost 13 million years to *Pierolapithecus*, the requirements of successful sensory processing and motor behaviors would seem to have remained relatively stable. Simply put, the physics for somatosensation, audition, and vision, and the biochemistry for taste and smell are stable and would have created a stable environmental context subserving the development of the senses. And none of these sensory challenges would be affected by an ultrasocial community context unique to modern human

cultures (e.g., Sterelny, 2007). Moreover, the senses as they developed would have created, perhaps, the primary root of the cognitive system. Hence, to a certain extent, one might effectively argue that while human cognition is a recent development, the approach to thought and the information on which we cogitate are rooted in very primitive and pre-Pleistocene perceptual functions; and even the thermodynamics of the universe.

The Problem with Evolution as Part of the Human Pleistocene

Above we reviewed several systems that seem to predate human evolutionary development. Similarly, Panksepp and Panksepp (2000) argued in their now well-cited paper, *The Seven Sins of Evolutionary Psychology*, that the human emotional and motivational systems in the brain are very ancient, and are indeed more ancient than the Pleistocene. As addressed in this essay and elsewhere, theorists in evolutionary psychology often propose that various mental faculties and abilities are fundamentally human in origin and adaptation. This seems to contradict a breadth of research in comparative neuroscience — hence the argument for an explicit set of guidelines to understand evolutionary forces with the “Seven Deadly Sins.” To paraphrase this argument, evolutionary psychology theorists have ignored neurobiological evidence which indicates that higher-level cognitive functions, and many conscious states of the human mind, are rooted in very primitive “hard-wired” affective and motivation systems found in all mammals (and many other phyla). In effect the proposed domain specificity of the human mind may be a result of the domain generality of the neocortex interacting with innate subcortical systems that evolved, and significantly predate, the Pleistocene. Certainly many of these principles apply directly to sensory mechanisms and their evolution. The problem, then becomes, how does one describe adaptations as human-based, or as human-evolution? Simply put, in structuring the problem in this manner we diminish the more longstanding and profound influences of the environment.

When it comes to perception, the fundamental evolutionary challenges have not dramatically altered with the advancements in human cognitive complexity. Essentially we maintain the same underlying needs to identify dangers from safety; food from toxin; comfort from pain. How we go about solving these problems has changed dramatically with cultural complexity and social change, but many of the fundamental perceptual problems have been addressed long before and with great success before any of these human-based progressions occurred. If one were to argue that human perceptual adaptations are, in fact, human-based, then one would necessarily argue that human-based perception is solving for a different environment, and set of challenges, that existed before our species. We contend that the environment does not require a species-specific mechanism, even if our particular niche may vary with phenotype. Perceptual mechanisms are simply and

directly required for interaction with that environment rather than a human-specific challenge. To address, interact, and understand our environment for successful perception we necessarily had to have effective perceptual mechanisms to support the emergence of our species. Fundamentally, the development of our species is subject to universal thermodynamic constraints and more specific, but enduring, dangers and comforts of our niche. Surely, there has been significant adaptation that is specific to the human brain and mind with respect to increasing cognitive complexity, but the crucial adaptations from which this subsequent evolution has taken place is much older. It is on these grounds that we contend that the human perceptual systems and mechanisms are adaptations that are not fundamentally human specific.

Moreover, if we were to suppose that human biological architecture and perceptual mechanisms emerged in the Pleistocene and thereafter, then we might predict unique mechanisms in the human visual, auditory, somatosensory systems relative to our closest genetic lineage via speciation. These mechanisms may well have varied as we incorporated social and technological advances that promoted a unique niche for humans relative to other species (e.g., Huffman, 1986; Ingold, 1996; Sterelny, 2007). Specifically, chimpanzees, or at least monkeys and other close mammals from which we have diverged in the pre-Pleistocene, should present numerous examples of unique speciated perceptual mechanisms or neural processing. While some differences do exist, the architecture, neural plasticity, and major perceptual obstacles (e.g., of finding food, sex, etc.), remain surprisingly consistent across our species. Again, the limited divergence suggests that the major evolutionary forces acted upon and instigated the development of common mechanisms, shared by humans, in the pre-Pleistocene. The examples put forward earlier in this essay indicate that other species may possess certain perceptual mechanisms also found in humans and show that perhaps the many perception–action links thought to exist in humans as having evolved in the Pleistocene may have actually evolved further in the past.

In the extant perceptual and cognitive literature, the human niche has received considerable attention. We have argued that the multiplicitious niche of our forebears that has structured pre-human species of various climates, size and space constraints, and hard-won survival mechanisms, are still a major influence in our genetic code and the foundations of modern perception/cognition. In focusing on adaptations only in our most recent epoch of evolution, we ignore the potentially critical shaping events that have biased our most recent adaptations. To paraphrase a now well-established idea, our brains are structured as a heterogeneity of mechanisms, processes, and parts (e.g., Cosmides and Tooby, 2013). This *mélange* of pieces presents a seemingly uniform cognitive state, while actually drawing on thousands of tiny biological hacks of nature's code. Limiting the scope of our thoughts to these most recent developmental eras constrains both our theories and imaginations to just the latest adaptations in a struggle for biological success that has endured for millions of years.

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