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The Divergence of Human Cognition from Other Primates

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Human cognition is a heavily researched and debated topic within the field of psychology. With contributions from many areas of research including, but not limited to, archeology, anthropology, paleontology, genetics and comparative psychology, science is gradually getting closer to uncovering precisely what makes the human mind so unique. Evolutionary psychology offers an especially valuable perspective as it looks at the timeline of human cognitive development and the divergence of modern humans from their close primate relatives. In this review, cognition will be used in the broad sense of the term, including functions such as language, cooperation, and culture, which together have allowed humans to function in large groups; causal reasoning and mental time travel, which amount to humans' ability to determine cause and effect and extend thought into the past and future; and metacognition and theory of mind, which facilitate an understanding of one's own beliefs and of others' perspective and beliefs, and how they may differ from one's own.

Attention will first be directed to the mechanisms which made human cognitive divergence possible, with specific investigation into why humans followed their own unique trajectory in comparison to other primates. This will be followed by a broader discussion of the particular cognitive features that are considered to separate humans from the other great apes, leading into a review of the competing arguments for which specific feature is the most exclusive to modern humans. Lastly, a dual-process approach will be introduced, which presents the difference between humans and other primates as a matter of degree rather than type. This approach suggests that there are two levels of cognition present in humans. Other primates possess the simpler level of cognition while humans have evolved a second tier. With research from all of the aforementioned domains considered, this paper will demonstrate that although there are many theories proposed to address human cognitive evolution, the dual-process

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approach seems most appropriate when attempting to tackle this perplexing issue (Shettleworth, 2012).

Human Cognitive Divergence

A common criticism of evolutionary psychology is that novel functions are shown to arise without any explanation of how they got there (Heyes, 2012). Therefore, scientists began to turn their attention to the actual processes and hypothesize what has influenced the drastic changes that were a part of human speciation. Heyes (2012) proposes that the evolution of human cognition took place through incremental co-evolution, further divided into two processes: gene-culture co-evolution and techno-social co-evolution. Gene-culture evolution is easily understood through the example of lactose tolerance. The process of dairy farming began, allowing those who possessed the genes that enabled digestion of dairy to prosper and reproduce more than those without, therefore leading to more dairy farming practice (Heyes, 2012). A specific gene interacts with cultural practices that align with it, and they encourage each other thereon out. Both of these co-evolution processes can be explained by a so-called positive feedback loop. In the case of techno-social co-evolution, technical advances began to be selected for, which required social cooperation in their use, thus triggering more technology to be developed. This pattern effectively encouraged both social skill and technical skill development within the species (Heyes, 2012). Following this pattern, as social skills developed, the stage was set for other cognitive abilities such as language and complex problem-solving to follow.

The question then must be asked: Why were these technical advances needed? Perhaps we can turn to archeological research to provide an explanation. Stuart-Fox (2015) explains that our ancestor, Australopithecus, lived in a remarkably unstable environment, which undoubtedly placed new pressures and demands on the species that the common ancestor of humans and chimps had not encountered. Not only did this result in physical changes like bipedalism and behavioural changes like an omnivorous diet, but it also proved a challenge psychologically for the primitive cognition of that time. The social brain hypothesis, which asserts that as the human brain was tested with new environmental demands it grew in size (Stuart-Fox, 2015), aligns with this view if we associate the growth of the brain with development of new cognitive abilities. The additional finding that group expansion also played a large role in human divergence is supported by others who agree that cultural evolution influenced the anatomical brain changes accompanying the split of humans and chimpanzees into different species (Heyes, 2012; Tomasello & Herrmann, 2010).

This increased cognitive ability, and subsequent increase in brain size has received much attention by researchers studying anatomical effects of human evolution. The expensive tissue hypothesis proposed by Aiello and Wheeler (1995) poses the notion that as the brain expanded, a downsizing of other organs, namely the gut, took place in order to maintain the optimal basal metabolic rate (Roberts & Thorpe, 2014). Figure 1 (Navarrete, van Schaik, & Isler, 2011) shows, in detail, the various components of the expensive tissue (or brain) hypothesis.

The exact order of this bodily shift is debated. Some argue that an initial change in diet led to a reduction in gut size and increase in cognitive ability, while others contend that brain expansion happened first to accommodate more advanced foraging methods, which then led to changes in gut size (Roberts & Thorpe, 2014). Researchers in the field of epigenetics also offer an explanation of this change with regard to gene regulation in humans compared to other primates. Càceres et al. (2003) found that 91 neuronal genes, some associated with learning and memory, were upregulated in the human cortex but not in chimpanzees or macaques. Figure 2 (Càceres et al., 2003) shows the differences in gene regulation of a specific enzyme, carbonic anhydrase II, within the cortex of humans, as compared to other primates.

This increase in activity would typically be quite challenging for mechanisms to maintain cell function, but humans do not appear to show the expected deficits. Càceres et al. (2003) conjecture that these changes may have been an adaptation for maintaining high levels of cerebral activity over the human life-span, which is longer than that of other primates. Whether these anatomical and cognitive cerebral developments were caused by environmental pressures, social requirements, or a combination of both, it is apparent that human brains differ significantly from their close primate relatives in many ways.

Distinguishing Traits and Factors Between Humans and Other Primates

One does not need to invest much time or effort into experimental research to conclude that humans prevail against other animals in most tests of cognitive ability and related intelligence. The human brain-to-body ratio is three times that of other great apes, and a fully-grown chimpanzee shows similar cognitive development to a two-year-old human (Tomasello & Herrmann, 2010). Further illustration of this point can be found in results of the False Belief test, which tests children’s Theory of Mind by asking them to look at a scenario from the perspective of another. In this experiment the child, along with another participant, observe an object being placed in an initial location, typically a box, after which the participant leaves the room. This is followed by the object being moved to a secondary location while the participant is absent. After the participant returns to the room the child is asked where the participant might look for the object. If the child suggests that they would look in the initial location, this indicates that despite the child seeing the object be moved, they realize that that is the last place the participant saw the object, showing that they possess Theory of Mind and therefore pass the test. Alternatively, if the child suggests that they would look in the secondary location, they have not yet grasped this concept and will fail, as most children under four years old do. Children older than four years old typically comprehend that others may possess different beliefs than them, but other primates of all ages fail, demonstrating that even young humans have cognitive abilities beyond nonhuman animals, specifically with regard to understanding others' perspectives and beliefs (Shettleworth, 2012).

Some may argue that animals do, in fact, exhibit human-like behaviour, and insist that we, as humans, cannot interpret intentional reasoning of animals that we cannot explicitly understand. Contrary to that belief, however, Penn et al.'s (as cited in Shettleworth, 2012) Relational Reinterpretation Theory explains that while animals and humans do share common mechanisms, humans have an understanding of the world that extends to unseen objects, unknown timeframes, or social forces that simply cannot be grasped by nonhuman animals. Shettleworth (2012) also points out that many tasks of the modern human mind involve the concept of recursion, which is the process of one concept being implanted within another concept of a similar kind. A common form of this is in planning, where aspects of the past are considered in a future context (Shettleworth, 2012). Recursion is not something that has been shown to be within any other mammals' capabilities beyond its most simplistic implications.

Most scientists agree that it is executive cognitive functioning that distinguishes humans from other primates; however, they have yet to come to a consensus on exactly which function is the most differentiating.

Causal Cognition

The aforementioned unstable environment that early hominins lived in is proposed to have led to a cognitive ability that is considered by some to be the leading cause of the divergence of humans. It is argued that this distinct feature emerged out of three human propensities: an innate curiosity, a tendency to categorize signs from nature within memory, and the ability to derive a causal connection between such signs (Stuart-Fox, 2015). Stuart-Fox (2015) argues that out of all other higher-order cognition, causal reasoning is the underlying factor behind them all. Colloquially speaking, the human drive to find the cause of a certain event is extremely evident in our society. One simply has to look to popular television programming and take note of the copious amounts of crime dramas, films that follow investigative teams, and even children's programs that centre around finding clues and solving mysteries. Stuart-Fox (2015) also points out that in our social environment we rely on receiving confirmation or disconfirmation from members of our social group, and if correct inferences are salient enough, the behaviour will be selected for and likely propagate into future humankind. This shows that a central part of our lives is connecting others' reactions with the behaviour that caused it. Evidence for the development of causal cognition is also shown by the fact that humans do not possess an impressive sense of smell or hearing; this points to the fact that hominins likely relied heavily on sight and vision in their fight for survival (Stuart-Fox, 2015). Another indication of the relevance of causal cognition is found in evidence from developmental research with infants and young humans. It has been shown that causal relationships begin to be explored by seven months of age (Newman et al., 2008). This is around the time that language begins to develop, suggesting that causal cognition has a similar level of importance to human life as language (Workman & Reader, 2014).

Working Memory

While some argue for causal cognition as the final puzzle piece in the modern human mind, Wynn and Coolidge (2011) insist that working memory was the latest development in the divergence of humans. It should be mentioned that some literature does not go along with this theory: Cook (2010) found in their study including young chimpanzees and university students, that the students actually performed worse than the chimps unless they had undergone training on the visual short-term memory task used in the study. Despite findings like this, working memory is one of the most heritable traits, with a combination of general and specific genetic influences (Wynn & Coolidge, 2011). Humans are undoubtedly unique in their executive functions of complex problem-solving and future-oriented planning and have even developed external systems on which to hold information, thereby freeing their own working memory systems for other tasks (Wynn & Coolidge, 2011). Modern day humans may utilize electronic devices or a simple paper and pen for this, but even hominin ancestors as far back as 28,000 years ago exhibited similar behaviours (Wynn & Coolidge, 2011). Even more interesting and suggestive of humans' advanced cognitive talents is the 32,000-year-old German statue of a lion-headed person shown in Figure 3. Not only does this figure demonstrate that humans used external sources to display their imagination, arguably a function of working memory, they also were capable of thought that stretched beyond reality (Wynn & Coolidge, 2011). They have found evidence for working memory in research on ancestral behaviour, in advanced tool production, foraging systems that required storing, and planning of delayed consumption and hunting schedules. These findings show that early hominins were well on their way to the higher-level cognition that modern human working memory is capable of (Wynn & Coolidge, 2011).

Cultural Learning

The concept of history is arguably uniquely human, as the species passes on culturally relevant information that undergoes changes and intensifications over time, so that new generations may be made aware of the method in which their society ought to live (Tomasello & Herrmann, 2010). This is not to say that other animals do not have a concept of the past that they learn from, but the way that humans accrete new concepts and pare out old ones is not observed across other species (Tomasello & Herrmann, 2010). Tomasello and Herrmann (2010) assert that the various skills, which have been addressed within in this paper, are developed within the framework of functioning in a cultural group. Humans have historically lived in larger and larger groups, and the social brain hypothesis attributes our larger cranial capacity to this very fact. Additionally, humans have been shown to have greater ability in the social domains of intention reading, social learning, and communication when compared with other primates (Shettleworth, 2012). In a study by Warneken, Chen, and Tomasello (2006), it was demonstrated that when engaged in a cooperative task with an adult, if the adult stops participating chimpanzees are found to continue the task individually, whereas human infants will attempt to reengage the adult in the task. While it has not yet been extrapolated whether this is due to a learning mechanism or an innate tendency toward cooperation, it is clear that cultural and social groups are of great importance to modern humans.

Dual-Process Theory

The final component to discuss is the notion that human cognition exists in the form of dual-processes that evolved as humans developed a second level of thinking. In addition to the pre-existing system that other species share with them, it is suggested that a more complex system of higher-order thinking began to exist in adult humans (Shettleworth, 2012). The external record-keeping of working memory that has previously been mentioned may in fact be an instance of these dual-processes at work. It is conceivable that the function of external-record keeping is an evolutionary adaptation, and the abundance of universally accessible information of the present day could be a modern manifestation of this (Wynn & Coolidge, 2011).

Support for the dual-process view has been shown in many experiments. Research by Weinstein, Bugg, and Roediger (2008) found that participants exhibited better recall for words that were associated with ancestral conditions, for example, performance was better in the scenario that used the term “grasslands” compared to the term “city.” This can be interpreted to suggest that there exists an underlying cognitive system that developed within the shared common ancestor, and may still be shared with other animals, and that humans have since advanced their cognition beyond that baseline. If this is the case, perhaps all the individual features identified to distinguish humans from other animals are merely exaggerations or extreme forms of mutually possessed abilities. Various factors such as diet, environment and culture placed enough pressure on our hominin ancestors for specific abilities to develop and be selected for, leading to speciation from the common ancestor and vast lifestyle changes to follow. By this logic, the higher-order thinking that allows for technological advances led by humans has its roots in the same cognitive system that allows chimps to break open shells of nuts with stones.

Concluding Remarks

Most researchers note, either verbatim or with a degree of paraphrasing, the well-known statement by Charles Darwin (1871) regarding differences between humans and other animals: “The difference in mind between man and the higher animals, great as it is, is one of degree and not of kind” (as cited in Stuart-Fox, 2013, p. 247). This is worth reiterating in this paper as it helps point out that while scientific research has come a long way and made many worthwhile discoveries, all these recent findings still relate back to something stated over a century ago. While extensive research has since taken place, this area of study is still rich with discoveries yet to be made. As pointed out by many researchers, due to the difficulty in comparing modern humans to their ancestors, we may never uncover an exact single cause of human divergence, if there even is one (Càceres et al., 2003). Alternatively, it may be the case that human cognitive evolution cannot be reduced to one factor, and all theories of cognitive mechanisms and abilities identified in these various articles each play an equally vital role in the process of human cognitive divergence.

Figures

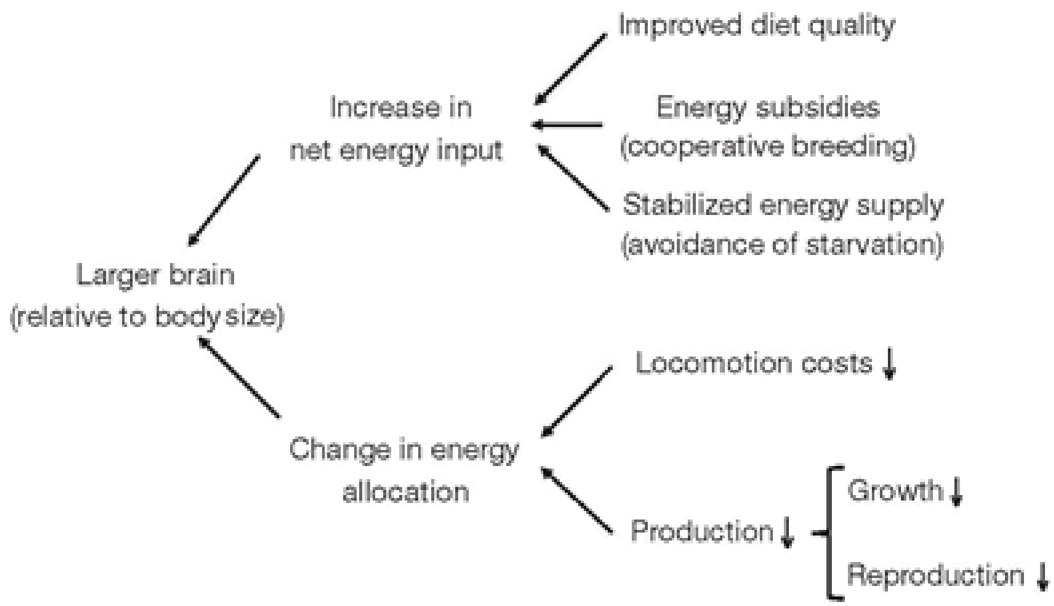

Figure 1. The expensive brain hypothesis. This figure illustrates the various influences on energy input that can affect brain size (Navarrete, van Schaik, & Isler, 2011).

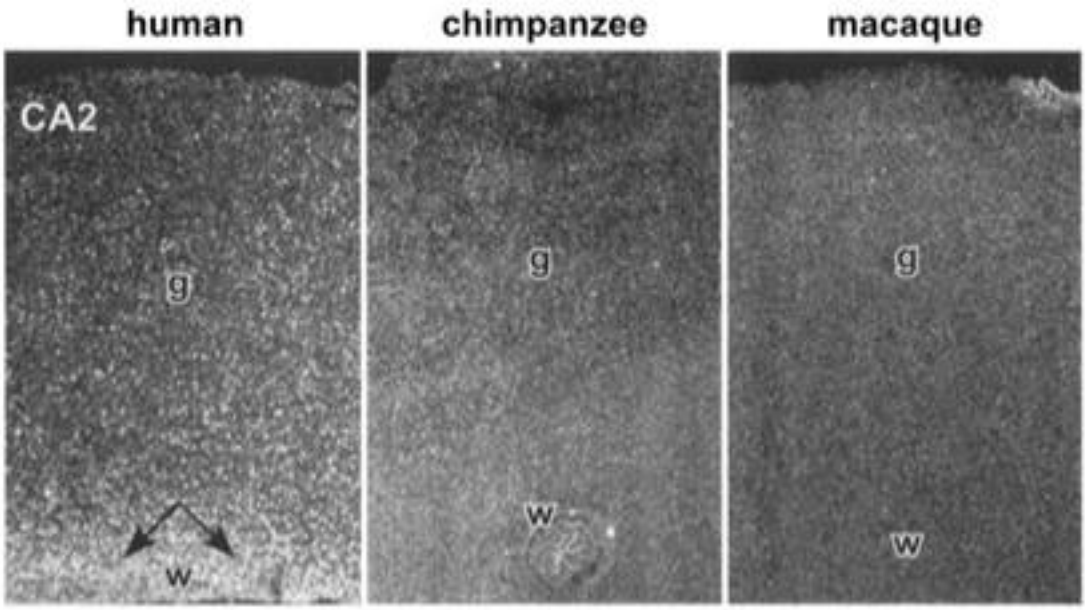

Figure 2. Differences in gene expression in human, chimpanzee, and macaque cortex. This figure shows the considerable upregulation of the enzyme carbonic anhydrase II in the human cortex when compared to chimps and macaques, seen in the concentration of white dots present (Càceres et al., 2003).

Figure 3. German statue of a lion-headed person. This 32,000-year-old figure demonstrates that humans used their working memory to show their imagination externally, as well as original thought to create non-existent creatures. (Wynn & Coolidge, 2011).

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