Book Review: The Evolution of Intelligence

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Book Review

The Evolution of Intelligence

A review of David C. Geary, *The Origin of Mind*. American Psychological Association, 2005, 459 pp. US$59.95 ISBN 1-59147-181-8 (hardback)

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Make no mistake about it, like Geary's previous book, *Male, Female* (1998), also written from an evolutionary perspective, *The Origin of Mind* is impressive. It constitutes a huge interdisciplinary synthesis of research on the brain, cognition, and intelligence. The reference section alone is larger than any of the nine individual chapters, spans 74 pages, includes approximately 1,100 references, and stands as stark testimony to the enormous amount of work and scholarship that went into this book. As a consequence, however, this is not a book for the novice.

After devoting a well-organized initial chapter to bringing readers up to speed on empirical research that successfully demonstrates Darwin's and Wallace's original propositions, Geary begins to flesh out his "motivation to control" theory, an organizing theme for the book, in Chapters 3 and 4. Simply stated, complex brains evolved because they allowed organisms to exert greater control over their environment. Geary argues that selection mechanisms led to changes in brain size in essentially the same way these mechanisms have been shown to act on other physiological and behavioral phenotypes.

Three specific selective agents are explored; climatic, ecological, and social. Geary discounts climatic influences on increased brain volume and EQ, noting that if decreased temperatures led to an increase in both body and brain size then other species would have experienced similar adaptations. Further, he points out that periods of climatic change do not coincide with periods of rapid brain increase, which presumably took place less than two million years ago according to the fossil record of *H. habilis* and *H. erectus*.

Geary expands upon Alexander's description of ecological dominance by emphasizing the subsequent social competition that ensued. It is this shift, from ecological (interspecies) to social (intraspecies) competition, which led to the evolution of the human brain. The propagation of behaviors that function to maintain ecological dominance also increase one's chances of social dominance and this provides the framework for Geary's motivation to control theory. As social groups became increasingly complex, psychological adaptations became essential to individual success within the group. Play during development, increased length of parenting, cooperative hunting, and specific cognitive mechanisms for conspecific manipulation are just a few of the behaviors that have evolved to control and manipulate social and ecological resources. Sexual selection has favored reproductive strategies that deal effectively with the competing interests of both same-sex competition and opposite-sex potential mates. Geary proposes that some of these same behaviors also set the stage for the evolution of general intelligence by introducing folk biology, physics, and psychology, which provide for mental representations of the biological, physical, and social world.

In chapter 5, Geary discusses different modular domains that have evolved to aid in the processing of ecological and social information. During human evolution, social selection pressures became increasingly tied to fitness and reproductive outcomes. This created an evolutionary arms-race of sorts for social intelligence as individuals struggled to outwit not only predators and prey, but each other. One result was the emergence of modular domains such as language, self-awareness, and theory of mind (inferring what other people may know, want, or intend to do). Geary contends that there is no hard evidence for these capacities in non-human primates or other creatures, at least not on the level of sophistication displayed in humans.

Humans' extraordinary mental abilities are not limited to those concerned with outwitting other humans (folk psychology). Also important are ways of representing and predicting the actions of physical objects (folk physics) and flora and fauna (folk biology). Geary states that many non-human animals display some capacity for folk physics, such as the ability to navigate. Humans, not surprisingly, tend to be particularly sensitive to object properties related to tool use.

Folk biology refers to the ability to categorize flora and fauna in one's local ecology. It involves a complex classification system, as well as an intuitive sense of each species' "essence." This essence is defined as organized knowledge of the salient characteristics of the species, which allows for the prediction of their behavior. Geary argues that there is no evidence that any non-human primates or other animals have this capacity for taxonomic organization, or the ability to understand the essence of other species.

To be sure, humans have an unusually advanced ability to predict the behavior of animals. However, this differs from the abilities of many non-humans in ways that may be more a matter of degree than kind. Although animals may not form "human-like" taxonomies, they often display an ability to discriminate between different species. Furthermore, many large-brained predators, such as lionesses, display group hunting strategies that rely on the ability to predict the behavior of particular prey species. Geary's argument against folk biology in non-humans only works when folk biology involves "explicit, taxonomic organization of related species", but the term "explicit" seems to make this ability either uniquely human or un-testable by definition. In the last analysis, folk biology in humans may simply be an expansion and refinement of abilities common among many different intelligent creatures.

Two abilities that may have developed as a consequence of human social competition are self-awareness and theory of mind. Geary suggests in Chapter 7 that these two abilities may have evolved together. Theory of mind allows one to detect acts of deception on the part of others, and make inferences about their underlying goals and motives. Self-awareness allows one to manipulate behavior in ways that disguise one's true intentions, thus making deception possible. Therefore, self-awareness is viewed as a counterstrategy to theory of mind in others, while theory of mind is a counterstrategy to self-awareness in others. The way Geary has framed these two abilities they must have emerged simultaneously and spontaneously.

A counter argument advanced a quarter of a century ago that Geary neglects to mention anticipated much of the current research on self-awareness, mental state attribution, and mental time travel (Gallup, 1982). According to this account, mental state attribution is a byproduct of self-awareness. Since the only experience you can ever experience is your own experience, experiences and mental states exist in others only by inference. And, of necessity, such inferences are made (at least initially) on the basis of one's own experience and mental states. Knowledge of self, in other words, paves the way for an inferential knowledge of others. Not only is this position consistent with what is known about the development and elaboration of these abilities in children, but there is growing evidence that conditions that lead to impaired self-awareness, such as autism, schizophrenia, and brain damage to the frontal cortex, are associated with correspondingly diminished/impaired abilities to infer what other people are thinking (Gallup and Platek, 2002).

In Chapter 8 Geary provides a detailed account of the research that has been done to identify the components of performance on standardized intelligence tests. A surprising amount of the variance in scores on these tests can be accounted for by individual differences in reaction time, inspection time, and working memory. Geary also reviews the evidence for the neurological basis of performance on intelligence tests as it relates to individual differences in brain size and differences in the importance of various brain areas. Evidence concerning the heritability of traits that contribute to intellectual functioning is also reviewed, along with evidence for the impact of environmental factors.

In the final chapter Geary provides an account of the impressive body of evidence implicating a strong and striking relationship between general intelligence and different social outcomes, such as educational achievement, job performance, and income. He also provides a detailed review of the various mechanisms that contribute to academic learning.

As much as we are impressed by this book, in the space that remains we will provide a few additional thoughts on the evolution of intelligence that are either missing or not adequately represented. In both Chapters 3 and 7 Geary considers but largely discounts the effect of climate variation as a factor in promoting human brain expansion. Geary's dismissal of the role of climate may be premature. It is important to bear in mind that there are two features to climate change that could have impacted human evolution. First are gradual directional changes in temperature (global cooling) along with oscillations in temperature that occur over thousands or even hundreds of thousands of years. In addition, there are recurring temperature changes on a much shorter, seasonal time scale that become amplified with greater geographical displacement from the equator.

Based on an archival sample of 109 fossilized hominid crania spanning the past two million years, it has been determined that a surprising amount of the variance in cranial capacity among these skulls can be accounted for by paleo-temperatures as indexed by sea surface temperature measurements and oxygen isotope analyses (Ash and Gallup, in press a). At 100,000 year intervals the correlation between cranial capacity and the standard deviation of oxygen isotope measurements over the past 1.9 million years was +.725, while the correlation between cranial capacity and mean sea surface temperature changes over the same period was -.661. In other words, for the skulls in this sample increased variation in global temperatures accounted for 52% of the variance in brain volume, while progressive changes toward global cooling accounted for 43% of the observed variance in cranial capacity.

On a shorter, seasonal time scale there is also contemporary as well as fossil evidence for a substantial effect of temperature variation on cranial capacity. Based on a sample of 122 contemporary ethnic populations involving data from over 20,000 people, Beals, Smith and Dodd (1984) found a 2.5 cm^3 increase in cranial capacity for every degree of latitude displacement from the equator. Taking into account the geographic site of each of the fossilized crania in the previous sample, it was discovered that over 22% of the variance in cranial capacity could be accounted for by distance from the equator (r = .478). In other words, as the magnitude of recurrent seasonal fluctuations in temperature increased during human evolution as a consequence of migration to the north or south of the equator there is evidence for a corresponding increase in brain size (Ash and Gallup, in press a). Indeed, there was an average increase of 8.27cm^3 in brain volume for each degree of latitude displacement from the equator among the skulls in this sample. Since the typical contemporary human brain is about 1200 cubic centimeters and consists of roughly 20 billion brain cells, each cubic centimeter contains roughly 16.7 million brain cells. Therefore, the net effect of progressive displacement from the equator involved the addition of hundreds of millions or even billions of brain cells (Ash and Gallup, in press b). While correlational data alone do not necessarily constitute evidence that migration away from the equator lead to increases in brain size, the fossil record clearly demonstrates that dramatic increases in cranial capacity did not predate and therefore promote northern migrations.

Geary’s argument, that if climate were important in prompting the evolution of larger human brains it would have produced similar effects in other species, is based on faulty evolutionary logic. Evolution does not occur by design, it occurs by selection, and the raw material for such selection consists of nothing more than random genetic accidents. Because different species are represented by non-overlapping gene pools, and each adaptation is a byproduct of unique, complex configurations of genetic accidents, there are any number of ways to skin the proverbial adaptive cat.

Solutions to problems posed by living under conditions in which there are wide seasonal fluctuations in temperature have taken different forms. Morphological and physiological adaptations to colder climates by different animals include metabolic changes, thermoregulatory mechanisms, fat deposits of stored energy, fur, down, and subcutaneous layers of fat to minimize heat loss, as well as hibernation and migration as a means of adapting to seasonal variation extremes. Humans, however, were able to adapt to global cooling and exploit areas displaced from the equator through a variety of increasingly more sophisticated cognitive and intellectual adaptations, such as more intricate patterns of cooperative hunting and the invention of more effective weapons and tools. Pressures for the development of improved clothing and shelter, along with mastering the use of fire further accelerated the development of cognitive and intellectual skills in humans needed to adapt to colder climates (Ash and Gallup, in press b).

Because at high latitudes plants die or become dormant in the winter, hunting and meat eating not only became a prominent form of subsistence for early humans, but meat consumption has interesting cognitive implications in its own right. Herbivores that forage for food typically obtain and eat small amounts of food intermittently. Because such food is often scarce, foraging can be a very time-consuming, almost never ending preoccupation for many species. In contrast, predators that track and kill large prey have a unique advantage. Upon making a kill, not only can they consume large quantities of meat and fat on a single occasion, but there is often more than enough food to last for several days or more. Since the caloric intake per meal is much greater, meat eating has the potential to free up a lot of spare time. Witness a pride of lions eating, sleeping, and languishing for days following a kill. For organisms with sufficiently large brains and a glimmering of self-awareness, meat eating has the potential to create free time that can be spent in self-reflection and in the pursuit of increasingly more abstract problem solving activities (Ash and Gallup, in press b).

Still another consideration as it relates to climate is the fact that brains cannot get any bigger than they can be effectively cooled. Even though human brains only account for about two-percent of our body weight, they consume over a third of our daily caloric intake and as a result generate a lot of heat. Based on the identification of an intricate system of veins that may have evolved to selectively cool the human brain, Falk (1990) has proposed what is known as the radiator hypothesis. The discovery of a more extensive system of diploic veins in contemporary human brains as compared to fossil hominids and nonhuman primates is consistent with this hypothesis (Falk and Gage, 1997). Indeed, species-typical human features such as bipedalism and the assumption of an upright posture function to more effectively drain warm blood from the brain, and the loss of body hair enables the surface of the skin to function as a radiator to dissipate heat and return cooled blood to the brain. The importance of effective brain cooling may also be related to the aforementioned correlations between global cooling and changes in hominid cranial capacity over the past two million years, as well the relationship between brain size and equatorial distance in both fossil hominids and contemporary humans.

Finally, in terms of the emphasis placed on evolution and intelligence, it is unfortunate that the work of Miller (2000) and Kanazawa (2004), although cited, is largely ignored. In spite of these limitations, however, we enthusiastically endorse this book as a valuable and impressive synthesis that should be read by anyone seriously interested in the origin of mind.

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