The Evolution of Mind

Fundamental Questions and Controversies

Edited by
STEVEN W. GANGESTAD
JEFFRY A. SIMPSON

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About the Editors

Steven W. Gangestad, PhD, is Distinguished Professor of Psychology at the University of New Mexico. His research has covered a variety of topics in evolutionary behavioral science, including the determinants of sexual attraction, changes in women's sexual psychology across the ovarian cycle, the effects of genetic compatibility between mates on relationship qualities, individual variation in developmental precision and its manifestations in neuropsychology, and influences of men's testosterone levels.

Jeffry A. Simpson, PhD, is Professor of Psychology and Director of the Doctoral Minor in Interpersonal Relationships at the University of Minnesota. His research interests include adult attachment processes, human mating, idealization in relationships, empathic accuracy in relationships, and dyadic social influence. Dr. Simpson is a fellow of the American Psychological Association and the Association for Psychological Science. He serves as Associate Editor for the *Journal of Personality and Social Psychology: Interpersonal Relations and Group Processes.*

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The Hominid Entry into the Cognitive Niche

H. CLARK BARRETT
LEDA COSMIDES
JOHN TOOBY

Why is the human mind designed in the way it is, and why does it seem to differ profoundly from that of even our closest living relatives? Traditionally, scholars have attempted identify *the* factor that they believe encapsulates human uniqueness: Big brains, intelligence, language, symbol manipulation, the capacity to imitate and to acquire culture, tool use, expanded working memory, sociality, understanding intentions, and self-awareness have all been proposed as candidates. Scholars have often been tempted to link their candidate difference to a single evolutionary selection pressure or event: East African drought, the ice ages, hunting, warfare, large social groups, and so on. In our opinion, the search for a single breakthrough capacity or a single cause of the unique features of human design distorts a balanced effort (1) to map correctly the mechanisms comprising our evolved, species-typical psychological architecture, and (2) to understand the numerous and distinct selection pressures that built them. A natural science of humans is not like physics—with a few underlying general laws waiting to be discovered in intellectual quantum leaps. It is more like inventorying and tracing out detailed circuit diagrams for each subsystem in a newly encountered and highly complex engineered system, such as an aircraft; that is, our psychological architecture appears be a heterogeneous collection of computational devices or programs, each shaped by different subcomponents of natural selection to serve distinct evolved functions. Because some of these programs can benefit from particular types of information produced by others, innovations in some devices will have far-reaching but specific consequences on a subset of the other mechanisms, while still maintaining many of their core similarities to homologous systems in other species. For example, the human ability to cooperate, read intentions, and represent dispositions—functional in their own right—have presumably reshaped some aspects of our mating psychology, contributing to the emergence of durable, quasi-exclusive mateships. Hence, it is better to make sense of our architecture's subcomponents—unique or not—in terms of their functions and coadapted functional interrelationships than to section off artificially those facets that are unique, and consider them in isolation. Accepting that many of our psychological mechanisms will have been modified over evolutionary time for diverse reasons, it is nevertheless possible to identify a loose theme that underlies some of the more radical features of human design. What appears most singular about human psychological evolution is the assembly or retooling of various adaptations to support our entry into what has been called *the cognitive niche* (Cosmides & Tooby, 2000, 2001; Tooby & DeVore, 1987). These species-transformative modifications are primarily related to the acquisition, manipulation, and application of information. A distinctly human niche was based on developing an unprecedented new subsistence economics of information and knowledge use, involving, for example, the greater use of lower quality information, the greater use of novel interrelationships among information, and breakthroughs in lowering the cost of acquiring and maintaining large bodies of information. Here we sketch some components of what we believe a full account will eventually include.

WHAT IS TO BE EXPLAINED?

Humans have vastly increased the number of pathways by which they reach diverse instrumental ends. What explains this dramatic broadening of successful action?

1. *Improvisational intelligence.* The systems that cause celestial navigation in birds, dead-reckoning in desert ants, and food aversion learning in

rats, humans, and other omnivores are the expressions of various dedicated intelligences. A "dedicated intelligence" is a computational system that evolved to solve a predefined, target set of problems, usually achieved through domain-specialized procedures that are designed to expect and to exploit evolutionarily enduring regularities in a given problem domain (e.g., the invariant mechanics of rigid objects in three-dimensional space). Dedicated intelligences evolve their solutions over evolutionary time in response to these regularities. "Improvisational intelligence," in contrast, refers to a (hypothetical) computational ability to improvise solutions in developmental time to evolutionarily novel problems. Humans seem to have this ability to an unparalleled degree. Although all organisms would benefit by having this capacity, *only one does,* implying that its computational implementation must have huge costs associated with it, or the preconditions for evolving it are low probability (i.e., its evolution was sensitively path-dependent), or both.

Its benefits are obvious. Most species are locked in coevolutionary, antagonistic relationships with prey, rivals, parasites, and predators, in which move and countermove take place slowly, over evolutionary time. Improvisation puts humans at a great advantage; instead of being constrained to innovate only in phylogenetic time, humans engage in ontogenetic ambushes against their antagonists, with innovations that are too rapid with respect to evolutionary time for their antagonists to evolve defenses by natural selection. Armed with this advantage, hominids have rapidly expanded into new habitats, developed an amazing diversity of subsistence and resource extraction methods, caused the extinctions of innumerable prey species in whatever environments they have penetrated, and generated an array of social systems, artifacts, and representational systems immensely greater than that found in any other single species. As a knowledge-using species, we occupy the *cognitive niche,* using improvisational intelligence to solve problems that other species might approach solely with highly specialized, rapidly deployed but somewhat inflexible computational and physical specializations (Tooby & DeVore, 1987).

2. *Improvisational intelligence depends on access to local, transient, and contingent information.* Contrast, for example, the food acquisition practices of a bison with that of a !Kung San hunter. The bison's foraging decisions are (presumably) made for it by dedicated intelligences designed for grass and forage identification and evaluation. These adaptations are (relatively) universal to the species, and operate with relative uniformity across the species range. In contrast, the !Kung San hunter uses, among many other non-species-typical means and methods, arrows tipped with a poison found

on only one local species of chrysomelid beetle, and toxic only during the larval stage (Lee, 1993). This method of food acquisition is not a species-typical adaptation: Not all humans use arrows, poison their arrows, have access to a beetle species from which poison can be derived, or even hunt. Nor are any of the component relationships—between beetle larva and poison, between arrows and poison, or even between arrows and hunting—stable from a phylogenetic perspective. Each relationship on which this practice is based is a transient and local condition, and these contingent facts are being combined to improvise a behavioral routine that achieves an adaptive outcome: obtaining meat. Whatever the neural adaptations that underlie this behavior, they were not designed specifically for beetles and arrows, but they exploit these local, contingent facts as part of a computational structure that treats them as instances of a more general class (e.g., living things, tools, projectiles, prey). To yield novel implications for action, elements in these bodies of information are also densely inferentially cross-linked across conceptual boundaries that are computationally impermeable for other species (Barrett, 2005b; Cosmides & Tooby, 2000, 2001).

3. *Getting information from others, as well as from one's own experience, via culture, dramatically lowers the cost of acquiring large enough bodies of local, contingent information, making improvisional intelligence cost-effective.* Cognitive mechanisms underlying cultural transmission coevolved with improvisional intelligence, distributing the costs of the acquisition of nonrivalrous information over a much greater number of individuals, and allowing its cost to be amortized over a much greater number of advantageous events and generations (Tooby & DeVore, 1987). Unlike other species, cultural transmission in humans results in the ratchet-like accumulation of knowledge (Richerson & Boyd, 2004).

4. *Language dramatically lowers the cost of socially sharing information.* Language is a human-specific set of cognitive adaptations (Pinker, 1994). It acquires special significance when considered as a central element in the hominid entry into the cognitive niche, because of its effects on the economics of information acquisition and use. Utterances are a low-cost way of sharing information about the habitat and social world: They solve coordination problems necessary for coalitional cooperation to occur; expand the number of minds that can jointly cooperate to improvise a tool, hunting method, or other novel solution to a problem; and allow these improvised solutions to be communicated to and thereby benefit kin and cooperative partners.

5. *Theory of mind mechanisms lower the cost of social inference, and hence of socially shared information.* The ability to make inferences about representations in the minds of others (Baron-Cohen, 1995; Leslie, 1987) dramatically facilitates language (Sperber & Wilson, 1995) and the social transmission of knowledge.

6. *Scope syntax: The successful harnessing of local, transient, and contingent information requires the emergence of a suite of cognitive adaptations that police the ever-shifting boundaries of applicability of sets of contingently true representations.* The problem with representing contingently true relationships is that—outside a narrow envelope of conditions where they are applicable—they are false and misleading. The substance taken from the larva for arrow making is toxic during one season, but not another, or in another area, or when taken from another species or life stage. This whole new universe of information could not have been exploited by humans without the coevolution of cognitive machinery for tracking and inferring the circumstances under which contingent information can be treated as true or must be quarantined off. The human mind contains a rich set of cognitive adaptations—a scope syntax (Cosmides & Tooby, 2000; Leslie & Frith, 1990)—for regulating the scope of applicability of representations about contingent information. These include conditional, suppositional, and counterfactual reasoning; the ability to decouple representations and bind them into separate, noninteracting sets; the ability to store representations with various tags of truth, falsehood, and degrees of belief; metarepresentations; and the ability to perform mental simulations offline, with inferential products decoupled from the behavioral consequences they would ordinarily trigger (Cosmides & Tooby, 2000, 2001; Leslie, 1987; Tooby & Cosmides, 2001). Even human oddities, such as fiction, become intelligible: Fiction is a set of contingent representations, useful for deriving generalizations, but in which the scope of direct applicability has shrunk to zero.

7. *Improvisational intelligence rests on a foundation of dedicated intelligences.* Unguided improvisational intelligence would suffer disastrously from combinatorial explosion, so it must instead include the participation of a large set of domain-specialized, inference systems that manifest dedicated intelligence (Cosmides & Tooby, 2001), including ones for object mechanics (Leslie, 1994), tool use (Defeyter & German, 2003; German & Barrett, 2005), intuitive biology (Barrett, 2005a; Medin & Atran, 1999), social inference (Baron-Cohen, 1995), social exchange (Cosmides & Tooby, 2005), and numerous others. These supply improvisational intelligence with many forms of useful inference to link representations together use-

fully, guiding thought away from vast spaces of barren and useless concatenation.

VIRTUOUS CIRCLES AND SELECTED RAMIFICATIONS

These adaptations both depend on, and make possible, scores of other modifications in human design. Here are two examples:

1. *Humans cooperate to an unprecedented extent.* Social exchange and reciprocation allow individuals to exploit transient differences in their momentary needs and values to achieve gains in trade. The human mind includes cognitive specializations for engaging in social exchange (Cosmides & Tooby, 2005), including *n*-party exchange (Tooby, Cosmides, & Price, 2005). Improvisational intelligence vastly expands the potential for mutually beneficial trade, but gains in trade from improvised solutions can only be achieved if potential cooperators can infer what others want, believe, and plan to do. Consequently, the theory of mind system (Baron-Cohen, 1995; Leslie, 1987) greatly facilitates cooperation. Humans also exhibit the zoologically rare ability to cooperate in large groups composed of unrelated individuals, greatly increasing the potential productivity of human labor, including, unfortunately, collective aggression.

2. *Male provisioning of women and children.* Although common in birds, male provisioning of females and offspring is rare among mammals, especially Old World primates. The increase in the improvisational ability to acquire previously unattainable high-quality foods, such as meat, shifted the cost-effectiveness for males of provisioning mates and offspring. Consequently, human males evolved motivational adaptations that make possible durable, high-investment mateships and extended relationships of paternal care. In turn, the expanded provision of meat and other high-quality nutrients provided the fuel necessary to support a developing brain made expensive by the addition of all the adaptations necessary to sustain improvisational intelligence, language, and cooperation (Kaplan & Robson, 2002; Wrangham & Conklin-Brittain, 2003).

In short, the ecological niche that humans entered is a novel one, involving the harnessing and exploitation of a kind of information that other species found too costly to acquire and too mercurial to trust: local, transient, contingent information.

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