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The Emergence of Evolutionary Psychology*

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Humans, like all other organisms, were created through the process of evolution. Consequently, all innate human characteristics are the products of the evolutionary process. Although the implications of this were quickly grasped in investigating human physiology, until recently there has been a marked resistance to applying this knowledge to human behavior. But evolution and the innate algorithms that regulate human behavior are related as cause and consequence: lawful relations are being discovered between the evolutionary process and the innate psychology it has shaped. These lawful relations constitute the basis for a new discipline, evolutionary psychology, which involves the exploration of the naturally selected "design" features of the mechanisms that control behavior. This synthesis between evolution and psychology has been slow in coming(see DeVore, this volume). The delay can be partly accounted for by two formidable barriers to the integration of these two fields: the initial imprecision of evolutionary theory, and the continuing imprecision in the social sciences, including psychology.

The revolution in evolutionary theory began two decades ago and, gathering force, has subsequently come to dominate behavioral inquiry. Vague and intuitive notions of adaptation, frequently involving (either tacitly or explicitly) group selection, were replaced by increasingly refined and precise characterizations of the evolutionary process (Williams, 1966; Maynard Smith, 1964; Hamilton, 1964). The application of these more precise models of selection at the level of the gene opened the door for meaningful explorations of a series of crucial behavioral problems, such as altruism towards kin, aggression, mate choice, parental care, reciprocation, foraging, and their cumulative consequences on social structure. These theoretical advances had their most dramatic impact on field biology, quickly reorganizing research priorities, and integrating the diverse studies of animal (and plant) behavior into a larger system of evolutionarily-based behavioral ecology (or sociobiology).

The heart of the recent revolution in evolutionary theory lies in the greater precision with which the concept *adaptation* is now used: the primary evolutionary explanation for a trait is that it was selected for; this means that it had or has the consequence of increasing the frequency of the genes that code for it in the population; if there is a correlation between a trait and its consequences, the trait can then be termed an *adaptation;* the means by which a trait increases the frequency of its genetic basis is called its *function.* There is no other legitimate meaning to adaptation or function in the evolutionary lexicon. Thus, the genes present in any given generation are disproportionately those which have had, in preceding environments, effective "strategies" for their own propagation. The traits individuals express are present because the genes which govern their development were incorporated in the genome because they have successful strategies of self-propagation. In other words, genes work through the individual they occur in, and the individual's morphology and behavior embody the strategies of the genes it contains.

The conceptual vagueness of the theory of natural selection, as it existed before these advances, meant that psychologists found little in it that they could meaningfully apply to produce coherent behavioral theories. However, instead of the earlier vague and impressionistic accounts of adaptation, modern behavioral ecology supplies a cogent set of specific predictions that are straightforwardly derived from a validated deductive framework. The mathematical and conceptual maturation of evolutionary theory has therefore removed one of the principal barriers to the creation of a coherent evolutionary psychology.

The second conceptual impediment has been the vagueness of psychology itself, both in its formulation of theories, and in its description of psychological phenomena. The field has floundered in a sea of incompatible and inchoate theories and interpretive frameworks since its inception. Despite the crippling limitations of the behaviorist paradigm, it is easy to sympathize with the driving motivation behind it: impatience and frustration with the incoherence and uninformativeness of unspecified and impressionistic

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assertions, theories, and descriptions. The rapid development of modern computer science, however, has begun to transform the field of psychology, especially in the last fifteen years. The capacity to specify intricate information-based dynamical procedures both legitimized and made feasible the construction of rigorously specified models of how humans process information. The creation of cognitive psychology has been one consequence. The methodological advances and insights of cognitive psychology have cleared away the last conceptual impediment to the development of an integrated evolutionary psychology by providing an analytically precise language in which to describe behavior-regulating algorithms. In fact, the "algorithmic" language of cognitive psychology and behavioral ecology dovetail together: *strategies* defined by ecological theory are the analytical characterizations of the selective forces that have shaped the proximate mechanisms that collectively comprise the psyche. The concepts (and technology) of computer science allow the formulation of dynamical decision structures and procedures that can tightly model the psychological algorithms which actually control behavior, guiding it onto adaptive paths. Starting from the realization that all of the psychological mechanisms are there *solely* because they evolved to promote the inclusive fitness of the individual, researchers can, for the first time, correctly understand the function of human psychological characteristics. Knowing the function of psychological mechanisms provides a powerful heuristic for defining them, investigating them, and evaluating hypotheses about their architecture.

As a result, the potential for advances in evolutionary psychology is beginning to be realized. The only remaining limitations are institutional: the psychological research traditions which antedate these advances in evolutionary theory remain insulated from and largely ignorant of their important uses and implications. There remains, of course, considerable vested interest in a corpus of research whose interpretive basis rests on obsolete assumptions.

Are humans immune to behavioral evolution?

This institutional resistance is manifested by the prevalent belief that while evolution shaped other species' psyches, it is irrelevant to human behavior, because of the existence of culture, intelligence, and learning. Thus, the argument runs, in the transition from simpler primate behavioral mechanisms, to the more elaborated and powerful ones we know to be present in modern humans, a crucial boundary was crossed. Many regard this, almost mystically, as a watershed transition which places human phenomena in another category entirely, beyond the capacity of evolutionary and ethological methods to study, model, or understand. They take the uniqueness of humanity (which is undoubted) to mean its incomprehensibility in evolutionary terms (e.g., Sahlins, 1976).

However, the immense increase in complexity of human (and protohuman) behavior is tractable to evolutionary psychology. Essential to evolutionary modeling is the distinction between proximate means and evolutionary ends. What proximate mechanisms are selected ("designed") to accomplish is the promotion of inclusive fitness. This end is fixed and is intrinsic to the evolutionary process. The mechanisms by which fitness is promoted may change over evolutionary time. However, the elaboration of mechanisms from the simple into the complex changes only the proximate means, not the evolutionary ends. In fact, such changes will occur only when they increase inclusive fitness, that is, only when they better promote the same evolutionary ends. Humans are characterized by a remarkable expansion in intelligence, consciousness (however defined), complex learning and culture transmission mechanisms, all interpenetrated by a sophisticated coevolved motivational system. But evolutionary psychology is uniquely suited to the analysis of these mechanisms, precisely because it analyzes mechanisms in terms of evolutionary ends, which do not change. As intelligence, learning, consciousness, and motivational systems progressively become more sophisticated, they still serve the same strategic ends according to the same evolutionary principles (Tooby & DeVore 1985).

Those who continue to assert that humans became immune to the evolutionary process, and are not significantly shaped by evolutionary principles, must somehow reason their way past the following fatal objection to both sophisticated and simple versions of their position. The innate characteristics whose genetic basis has become incorporated into the human genome were incorporated because they increased inclusive fitness, and therefore they are adaptively patterned. To assert anything else is to maintain that somehow a large number of less fit innate characteristics (those which did not correlate with fitness) displaced those that were more fit. In other words, they are faced with explaining how evolutionary processes systematically produced maladaptive traits. Usually, this kind of thinking is based on the notion that culture replaces evolution, and has insulated human behavior from selective forces. However, the existence of culture can only mean that natural selection produced and continues to shape the innate learning mechanisms which create, transmit, and assimilate cultural phenomena. These innate learning mechanisms, as well as their associated innate motivational, emotional, and attentional systems, control what humans choose to learn, what sorts of behavior they find reinforcing, and what goals they pursue, rather than the precise means by which they pursue them. Humans are unique in means, not in ends. The residual sense in the cultural insulation argument is the sound but simple one of phylogenetic lag: modern humans have emerged so rapidly from Pleistocene conditions that their mechanisms are still following the programming of what would have been adaptive under Pleistocene conditions.

In fact, sophisticated hominid mechanisms, instead of being divergent from evolutionary principles, may more purely incarnate adaptive strategies. Hominids' more intelligent, flexible and conscious systems are less limited by mechanistic and informational constraints, and can more sensitively track special environmental, historical, and situational factors and make appropriate adaptive modifications. Evolutionary processes select for any behavioral mechanism or procedure, no matter how flexible or how automatic, that correlates with fitness.

The set of behaviors which lead to survival and genetic propagation are an extremely narrow subset of all possible behaviors. To be endowed with broad behavioral plasticity is an evolutionary death sentence unless this plasticity is tightly bound to a "guidance system" which insures that out of all possible behaviors, it is those that promote inclusive fitness which are generated. Selection for plasticity must have been linked to the development of such a sophisticated guidance system in humans, or it could never have occurred. In fact, the primary task of human evolutionary psychology is the elucidation of this constellation of guiding algorithms. The existence of this guidance system prevents the "escape" of human behavior from analysis by evolutionary principle. Evolutionary psychology is not thwarted by hominid singularity. Evolutionary analysis shows hominid uniqueness to be rule-governed rather than imponderable. While it may prove that many hominid adaptive elements are combined in novel ways, this does not mean they are put together in random or unguessable ways.

Some early successes in evolutionary psychology.

Despite the fact that cognitive psychology has developed, by in large, uninfluenced by evolutionary biology, the realities of the human mind are forcing cognitive psychologists towards many of the same conclusions implicit in the evolutionary approach. Researchers in artificial intelligence have been chastened in their attempts to apply cognitive theory to produce actual (computational) performance. Simple associationistic theories of learning proved completely inadequate. They discovered that in order to get a system to do anything interesting (such as "see," learn syntax, analyze semantic content, manipulate objects in a three-dimensional world, etc.), they had to provide the program with massive amounts of specific information about the domain the program was supposed to learn about or manipulate; in other words, they had to give the computer a great deal of "innate knowledge." This phenomena is so pervasive and so well-recognized that it has a name: the frame problem (Boden, 1977). Moreover, the program had to contain highly structured procedures specialized to look for exactly those types of relationships which characterized the problem domain. Such procedures correspond to innate algorithms in the human psyche. It was possible to be an extreme environmentalist only as long as the researcher was not forced to get too specific about how performance was actually achieved. In artificial intelligence, this was no longer possible.

These realizations were foreshadowed by developments in psycholinguistics. Because syntax constituted a formally analyzable system, Chomsky was able to show that humans must have a powerful innate language-acquisition device in order to learn it. In Chomsky's phrase, the stimuli (the utterances of adults) were too impoverished to provide sufficient information for a child to learn the correct grammar through induction (Chomsky, 1975; Wanner & Gleitman, 1982). Humans had to have innate expectations or algorithms constraining the possible set of grammatical relations. This led Chomsky to beliefs similar to those implicit in evolutionary psychology: that the mind is composed of "mental organs" just as specialized in function as our physiological organs are.

By recognizing that the mind includes domain-specific algorithms or modules which are "designed" for or adapted to specific purposes, rapid progress has been made on a number of problems. For example, Marr (1982) uncovered the outlines of how the mind constructs three-dimensional objects from a two-dimensional retinal array. Roger Shepard, reasoning soundly from evolutionary principle, has demonstrated that the algorithms that govern our internal representations of the motions of rigid objects instantiate the same principles of kinematic geometry that describe the motion of real objects in the external world. Experimental evidence from perception, imagery, apparent motion, and many other psychological phenomena support his analysis (Shepard, 1984). As he points out, "through biological evolution, the most pervasive and enduring constraints governing the external world and our coupling to it are the ones that must have become most deeply incorporated into our innate perceptual machinery" (Shepard, 1981). Motivated by similar considerations, Carey and Diamond (1980) provide persuasive evidence from a wide array of psychological and neurological sources that humans have innate face-encoding mechanisms. Daly and Wilson, in a series of important studies, have found strong evidence indicating evolutionary patterning in such diverse phenomena as homocidal behavior, differential parental care, and sexual jealousy (Daly & Wilson, 1980; 1981; 1982; Daly, Wilson & Weghorst, 1982).

The extensive literature on human reasoning provide an opportunity for the demonstration of the usefulness of the evolutionary approach. Research on logical reasoning showed that humans frequently reasoned illogically, when the standard for valid reasoning was adherence to formal logic (Wason and Johnson-Laird, 1972). The conclusions people arrive at varies widely depending on the specific content they are asked to reason about. Research on so-called content effects in logical reasoning has been bogged down in a quagmire of conflicting results and interpretations, and none of the prevailing hypotheses have demonstrated any predictive power.

Cosmides (1985) has productively reorganized this confused literature through the application of the evolutionary approach. The content effects become very orderly when they are scrutinized for the presence of evolutionarily significant content themes. Psychological mechanisms evolved to handle important and recurrent adaptive problems (such as face recognition, mentioned above), and one crucial adaptive problem for humans is social exchange. Trivers (1971) and Axelrod & Hamilton (1981) demonstrated that cooperation can evolve only if individuals identify and bestow benefits on those likely to reciprocate and avoid such deferred exchange relationships with those who "cheat" through inadequate reciprocation. Because such cooperative labor and food-sharing exchanges have typified human hunter-gatherer bands throughout their evolutionary history, humans have depended on the evolution of a cognitive/motivational mechanism that detects potential cheaters in situations involving social exchange. Cosmides (1985) showed that an adaptive logic designed to look for cheaters in situations of social exchange predicts performance on logical reasoning tasks which involve such social content. Her elegant series of experiments have provided solid support for the hypothesis that humans have an innate special-purpose algorithm which structures how they reason about social exchange, with properties that differ markedly from formal logic. Not only do humans have an innate language-acquisition device, but they appear to have a collection of innate inferential networks which structure their reasoning about the social world.

Indeed, the evolutionary approach contains the potential for clarifying the murky area of emotion, and its relation to cognition (Tooby & Cosmides, in press). If the mind is viewed as an integrated architecture of different special-purpose mechanisms, "designed" to solve various adaptive problems, a functional description of emotion immediately suggests itself. Each mechanism can operate in a number of alternative ways, interacting with other mechanisms. Thus, the system architecture has been shaped by natural selection to structure interactions among different mechanisms so that they function particularly harmoniously when confronting commonly recurring (across generations) adaptive situations. Fighting, falling in love, escaping predators, confronting sexual infidelity, and so on, have each recurred innumerable times in evolutionary history, and each requires that a certain subset of the psyche's behavior-regulating algorithms function together in a particular way to guide behavior adaptively through that type of situation. This structured functioning together of mechanisms is a mode of operation for the psyche, and can be meaningfully interpreted as an emotional state. The characteristic feeling that accompanies each such mode is the signal which activates the specific constellation of mechanisms appropriate to solving that type of adaptive problem.

To make this concrete, let us briefly describe in these terms what might happen to a hypothetical human hunter-gatherer when a distant lion becomes visible. The recognition of this predator triggers the internal "broadcast" of the feeling of fear; this feeling acts as a signal to all of the diverse mechanisms in the psychological architecture. Upon detecting this signal, they each switch into the "fear mode of operation": that is, the mode of operation most appropriate to dealing with danger presented by a predator. The mechanism maintaining the hunger motivation switches off and cognitive activity involved in reasoning about the discovery of food is stopped, neither being appropriate. A different set of motivational priorities are created. Mechanisms regulating physiological processes issue new "instructions" making the person physiologically ready for the new sorts of behaviors which are now more adaptive: fighting or, more likely, flight. Cognitive activity switches to representations of the local terrain, estimates of probable actions by the lion, sources of help and protection from the lion, and so on. The primary motivation becomes the pursuit of safety. The modes of operation of the perceptual mechanisms alter radically: hearing becomes far more acute; danger-relevant stimuli become boosted, while danger-irrelevant stimuli are supressed. The inferential networks underlying the perceptual system interpret ambiguous stimuli (i.e., shadows, masking noise) in a threatening way, creating a higher proportion of false positives. Attention-directing mechanisms become fixed on the danger and potential retreats.

In this view, emotion and cognition are not parallel processes: rather emotional states are specific modes of operation of the entire psychological architecture. Each emotional state manifests design features "designed" to solve particular families of adaptive problem, whereby the psychological mechanisms assume a unique configuration. Using this approach, each emotional state can be mapped in terms of its characteristic configuration, and of the particular mode each identifiable mechanism adopts (motivational priorities, inferential algorithms, perceptual mechanisms, physiological mechanisms, attentional direction, emotion signal and intensity, prompted cognitive contents, etc.).

Evolutionary psychology employs functional thinking, that is, the modern rigorous understanding of adaptive strategies, to discover, sort out, and map the proximate mechanisms that incarnate these strategies. In so doing, it appears to offer the best hope for providing a coherent and unified deductive framework for psychology. Sciences make rapid progress when they discover the deductive framework that is appropriate to their phenomena of study. Fortunately, there exists in biology a set of principles with the requisite deductive power: evolutionary theory. We know that humans evolved, and that the mechanisms that comprise our psyches evolved to promote fitness. Our innate psychological algorithms are rendered comprehensible by relating them to a rigorously characterized evolutionary process. These realizations can organize research efforts in psychology into valid and productive investigations, because evolutionary analysis provides the level of invariance with reveals behavioral variation to be part of an underlying system of order (Cosmides, 1985; Tooby and DeVore, 1985; Tooby and Cosmides, in press).

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