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4,000 or 1,000 Hz, and the masker is separated in frequency from the probe by more than two octaves. The stimuli are usually 500 ms in duration and are presented at 60 to 75 dB SPL, usually in a background of continuous, wide-band, low-intensity noise that serves to mask the listener's ability to lis-

ten in frequency regions outside those associated with the probe, masker, or both.

8. The explanation of CMR and MDI based on fusing spectral components that are comodulated is only one of a number of proposed explanations for the phenomena.

Human Nature, Individual Differences, and the Importance of Context: Perspectives From Evolutionary Psychology

W. Todd DeKay and David M. Buss

Evolutionary psychology is emerging as an important theoretical perspective in many branches of psychology: cognition,¹ perception, psycholinguistics,² social psychology,³ developmental psychology,⁴ clinical psychology, and personality psychology.⁵ Its promise lies not in supplanting other psychological perspectives or research programs, but rather in adding additional layers of analysis and understanding to human psychological phenomena. Evolutionary psychology starts by posing three important questions that have been relatively neglected over the past century: What are the ori-

gins of human psychological mechanisms? What adaptive problems selected for their existence? What functions were they designed to serve?

Most psychologists are Darwinian in the sense that they believe that evolutionary processes are responsible for human origins.⁶ It is widely recognized that the only available alternatives—creationism and "seeding theory"—offer no real scientific value. The crucial issues are which evolutionary processes have shaped human psychological mechanisms and how these mechanisms have been shaped. Among the major evolutionary processes—mutation, inheritance, drift, isolation, and selection—it is generally recognized that natural selection, or the differential reproduction of genetic variants by virtue of differences in design, is the principal guiding force in the creation of complex, functional mechanisms known as adaptations.

The focus on selection as the key causal process has some heuristic value, but by itself does not get us very far. Evolutionary theory at this general level of abstraction offers only a few predictions (e.g., that adaptations cannot exist exclusively for the benefit of another species or conspecific competitors) and only

the crudest heuristic value (e.g., events surrounding survival and reproduction take on special importance). Evolutionary psychology, in contrast, combines the principles of natural selection with (a) specific evolutionary subtheories, such as the theory of parental investment and sexual selection; (b) an analysis of the specific adaptive problems humans have faced over evolutionary history; and (c) specific models of psychological mechanisms and behavioral strategies that may have evolved as solutions to those adaptive problems. Evolutionary psychology acquires the heuristic and predictive value we associate with powerful scientific theories when these conceptual elements are combined.

EVOLVED PSYCHOLOGICAL MECHANISMS

Since the cognitive revolution, psychologists have become increasingly aware of the need to understand decision-making rules and other information processing devices in the head. But although most psychologists have jettisoned behaviorism's unworkable antimentalism, many have retained the behavioristic assumption of equipotentiality and assumed that cognitive mechanisms are general-purpose, free of content-specialized procedures.⁷ Because psychological mechanisms are often presumed to operate in the same manner regardless of content, the selection of stimuli used in cognitive experiments has often been arbitrary, stripped of context, content, and meaning to the organism—

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nonsense syllables provide a prototypical exemplar.

Evolutionary psychologists, in contrast, argue that evolved psychological mechanisms cannot be solely general-purpose, are highly likely to be saturated with content, and operate differently in response to external input about different adaptive problems.⁷ Just as the body contains a large number of specific and dedicated physiological mechanisms (taste buds, sweat glands, lungs, heart, kidneys, larynx, pituitary gland), so, according to evolutionary psychologists, the mind contains a large number of specialized psychological mechanisms, each "designed"⁸ to solve particular adaptive problems. Because what constitutes a "successful solution" to adaptive problems differs across domains (e.g., criteria for food selection differ from criteria for mate selection), the requisite psychological solution mechanisms are likely to be special-purpose and domain tailored.

Some psychologists do not realize that manifest behavior depends on psychological mechanisms plus inputs into those mechanisms, both environmental and interoceptive. Environmental inputs alone cannot cause behavior in the absence of psychological mechanisms designed to process input. If a human, a chimp, and a dog react differently to identical environmental cues, it is because there is something different about the psychological mechanisms of the human, the chimp, and the dog. The central goal of evolutionary psychology is to identify these evolved psychological mechanisms and to understand their functions.

THE CENTRALITY OF CONTEXT IN EVOLUTIONARY PSYCHOLOGY

A common misconception about evolutionary approaches is that they

postulate "instincts"—rigid, genetically inflexible behavior patterns that are invariantly expressed and unmodifiable by the environment. Although this view may have characterized some previous evolutionary perspectives, nothing could be farther from the current views in evolutionary psychology.

Contextual evolutionary analysis takes place at several levels in the causal sequence leading to manifest human behavior. One is the *historical context*—the selection pressures that humans and their ancestors have faced over thousands of generations. Because we share part of our evolutionary history with other species (e.g., humans and chimps share common ancestors), we share some mechanisms with those species (e.g., mechanisms of vision). But because human evolutionary history differs from that of all other species and the selection pressures we experienced were different in many ways (e.g., importance of long-term reciprocity, degree of group-on-group warfare, magnitude of male parental investment), many of our evolved psychological mechanisms are unique to us (e.g., those underlying complex toolmaking and tool use, language, culture, and consciousness). Evolutionary psychology requires an analysis of both these shared and unique features of our historical context.

A second level of contextual analysis in evolutionary psychology is *ontogenetic*. Evolutionary analyses of ontogenetic context have taken two forms. First, experiences during development can dispose individuals toward different strategies.⁵ There is some evidence, for example, that absence of the father during childhood shunts individuals toward a more promiscuous mating strategy, whereas the presence of an investing father during childhood shunts individuals toward a more monogamous mating strategy.⁴ Clearly, more research is needed to verify this finding. Second, develop-

mental experiences may set different thresholds on species-typical psychological mechanisms. The threshold for responding to a threat with extreme violence is apparently low in some cultures, such as among the Yanomamo Indians of Brazil, and is high in others, such as among the !Kung San of Botswana. Ontogenetic contexts include, of course, sex-differentiated socialization as well as culturally variable input.⁷

The third level of contextual analysis entails description of the *immediate situational inputs* that activate particular psychological mechanisms. Just as callous-producing mechanisms are activated only if a person experiences repeated friction to the skin, so psychological mechanisms such as those responsible for sexual jealousy,⁹ detection of cheaters,¹ or discriminative parental solicitude¹⁰ are activated only by particular contextual input such as cues to infidelity, cues to nonreciprocation, or the simultaneous presence of genetically related children and stepchildren, respectively.

A central goal of evolutionary psychology is to explicate historical, ontogenetic, and situational forms of contextual input.

HUMAN NATURE AND CULTURAL VARIATION

A long-standing dogma in this century's social science has been that the nature of humans is that they have no nature, except perhaps a few highly domain-general learning mechanisms. Evidence that such a view is empirically untenable has been accumulating over the past decade.¹¹ Conceptual analyses by scientists in artificial intelligence, psycholinguistics, cognitive psychology, and evolutionary psychology are showing why such a view is untenable even in principle.⁷ Humans could not possibly perform the numerous complex, situationally

contingent tasks that they do routinely without considerable intricate and domain-dedicated psychological machinery. These psychological mechanisms, coupled with the social, cultural, and ecological inputs that reliably activate them, and linked to the adaptive problems they were "designed" to solve, provide a starting point for a description of human nature.

Although exactly which couplings are part of human nature must be determined empirically, possible candidates include childhood fears of loud noises, darkness, snakes, spiders, and strangers; characteristic emotions such as anger, envy, passion, and love; characteristic facial expressions such as those showing happiness and disgust; competition for limited resources; specific mate preferences; classification of kin; love of kin; preferential altruism directed toward kin; socialization from senior kin; play; deceit; concepts of property; enduring reciprocal alliances or friendships; retaliation and revenge; sanctions for crimes against the group; rites of passage; concepts of self; concepts of intentions, beliefs, and desires as part of a theory of mind; status differentiation; status seeking; prestige criteria; humor; gender terminology; sexual attraction; sexual attractiveness; sexual jealousy; sexual modesty; toolmaking; tool use; tools for toolmaking; weapon making; weapon use; coalitions that use weapons for war; collective identities; cooking; coyness; crying; and probably hundreds more (see Brown¹¹ for an extended list of possibilities).

Hearing references to concepts like human nature, evolved mechanisms, and evolutionary biology, people tend to think the reference is to robotlike automatons, rigidly programmed by genes to carry out activities that are inflexible and impermeable to environmental, social, and cultural influences. Even the most casual observation shows that

people are not like this. We respond with enormous flexibility and variability to even the slightest shifts in context. This observation, reasonably enough, causes most scientists to reject notions of instinctual rigidity, programmed inflexibility, and environmental unmodifiability.

A central message of evolutionary psychology is that the enormous flexibility and context contingency of human behavior *requires* a highly articulated, extremely complex architecture of dedicated, species-typical psychological mechanisms. Without those mechanisms to guide action, the islands of adaptive solutions could never be discovered amid the expansive oceans of maladaptive possibilities.

SEX DIFFERENCES

Evolutionary psychology provides a powerful framework for predicting when we should and should not expect sex differences. Men and women are expected to differ only in the delimited domains where they have faced different adaptive problems over the course of human evolutionary history. In domains where the sexes have faced the same adaptive problems, no sex differences are expected.

Historically, men and women have faced many adaptive problems that are highly similar. Both sexes needed to maintain body temperature (adaptive problem of thermal regulation), so both sexes have sweat glands and shivering mechanisms. Repeated friction to certain areas of the skin was damaging to both sexes in ancestral environments, so both sexes have callous-producing mechanisms. Analogously, both sexes needed to solve the adaptive problem of identifying a good cooperater when seeking a long-term partner, and this may be one reason why both sexes, across all cultures whose partner prefer-

ences have been studied, value kindness in a partner so highly.¹²

In several domains, however, the sexes have faced different adaptive problems. For 99% of human evolutionary history, men faced the adaptive problem of hunting and women of gathering, possible selective reasons for greater male upper body strength and spatial rotation ability and for greater female spatial location memory.¹³ Internal fertilization and gestation produced an adaptive problem for men, but not for women, of uncertainty of parenthood. Cryptic or concealed ovulation may have created the adaptive problem for men of knowing when a female was ovulating. The dual male mating strategy, seeking (a) short-term sex partners with little investment and (b) long-term marriage partners with high investment, created for women an adaptive problem of having to discern whether particular men saw them as temporary sex partners or as potential spouses.¹⁴ Sex differences in mate preferences,^{12,15} courting strategies,¹⁴ and sexual fantasies¹⁶ correspond remarkably well to these sex-linked adaptive problems. Evolutionary psychology offers the promise of providing a powerful and coherent theory of sexual differences as well as sexual similarities.

INDIVIDUAL DIFFERENCES

Evolutionary psychology aspires to understand not just our species-typical, sex-differentiated, and culturally differentiated nature, but also the ways in which individuals differ within species, within sex, and within cultures. Several promising avenues of investigation are being pursued. One approach attempts to understand individual differences resulting from different experiences during development. The father-absence versus father-presence theory of individual differences in mat-

ing strategies developed by Draper and Belsky⁴ represents a fascinating example of the developmental evolutionary psychological approach.

A second approach examines individual differences as a function of different environments that are currently inhabited. People married to partners who are perceived by others as relatively desirable, for example, may be reliably prone to jealousy over time, not because they are inherently "jealous people," but because they inhabit an enduring environment that recurrently activates jealousy mechanisms.

A third approach examines what may be termed "reactive individual differences." Individuals who are mesomorphic are better able to carry out an aggressive strategy, whereas those who are ectomorphic may perforce cultivate diplomatic skills.¹⁷ In this example, it is not the case that some individuals are innately more aggressive or agreeable, but rather that all people have the potential for both characteristics, and the strategy that gets adopted is contingent on species-typical decision rules that evaluate anatomical input and strategic success.

A fourth evolutionary approach to individual differences develops models of frequency-dependent selection that predict genetic differences among members of the same sex. Gangestad and Simpson,¹⁸ for example, have explored individual differences in "sociosexual orientation," the degree to which individuals seek sex with many partners with low investment in each versus with few partners with high investment in each. They present evidence that these individual differences may be heritable, may be bimodally distributed, and may covary with other personality characteristics in ways that support a conception of evolved strategy differences.

Because the analysis of individual differences represents the most recent and least explored avenue of inquiry within evolutionary psychol-

ogy, it is not clear which among these four approaches (or alternative approaches) will prove most useful. Indeed, some represent competing approaches to the same set of phenomena. Draper and Belsky,⁴ for example, propose that differences in mating strategy stem from critical events during development, whereas Gangestad and Simpson¹⁸ propose that they stem from heritable differences caused ultimately by frequency-dependent selection. Both approaches, however, represent improvements over prior evolutionary approaches that examined sex differences in mating strategies but ignored individual differences within sex in the strategies adopted.

THE EVOLUTIONARY PSYCHOLOGY OF JEALOUSY: A CASE EXAMPLE

No evolved psychological mechanism has been explored comprehensively in all its facets, including the historical selection pressures that forged it, its ontogenetic context, the situational inputs that activate it, its species-typical nature, and its sex-differentiated, age-differentiated, culturally differentiated, and individually differentiated features. In this sense, evolutionary psychology offers a promissory note, and it is reasonable to hold it to a rigorous theoretical standard: What new insights are gained by adopting this perspective? Its value, like the value of all theoretical perspectives, must be gauged by its conceptual and empirical harvest.

This section explicates one case that illustrates the potential payoff of evolutionary psychology—the psychology of jealousy. Jealousy is neither a peripheral nor a trivial emotion, for it is experienced in all known cultures and is the leading cause of spousal battering and homicide worldwide.¹⁰ Why do humans experience jealousy? Do the sexes

differ in events that elicit its expression? What contexts activate jealousy? And of what value is evolutionary psychology in shedding light on this pervasive and sometimes deadly mechanism?

Jealousy is a cognitive-emotional-motivational complex that is activated by threat to a valued relationship. It is considered sexual jealousy if the relevant relationship is a sexual one, but there are types of jealousy that do not involve sexual threat. Jealousy is often activated by cues to the apparent loss of key resources provided by the relationship—cues such as eye contact between one's partner and a rival, decreased sexual interest on the part of one's partner, and a partner's increase in flirting with one's same-sex competitors. Jealousy channels attention, calls up relevant memories, and activates strategic cognitions. Ultimately, it may motivate actions designed to reduce or eliminate the threat, retain the valued relationship, and hence retain the valued resources it provides.

Because both men and women over evolutionary history have been damaged by relationship loss, both sexes have faced adaptive problems to which jealousy may have evolved as one solution. There are no evolutionary grounds for predicting that one sex will be more jealous than the other, and indeed nearly all studies show that the sexes are equally jealous in global measures of jealousy magnitude. Jealousy appears to be a species-typical mechanism in both men and women.¹⁰

But several evolutionary psychologists have predicted that the sexes will differ in the events that activate jealousy.^{10,19} Because fertilization and gestation occur internally within women and not men, over evolutionary history men have faced an adaptive problem not shared by women—paternity uncertainty. The reproductive threat to a man would have come centrally from the possibility of sexual infidelity by his part-

ner, whereas a woman's certainty in genetic parenthood would not have been compromised if her partner had sex with other women. Women, however, may have risked the loss of a partner's time, attention, commitment, protection, investment, and resources—resources that could be diverted from a woman and her children toward another woman and unrelated children. For these reasons, evolutionary psychologists have predicted that the inputs that activate jealousy for men will be biased toward cues that relate to the sex act per se, whereas the inputs that activate jealousy for women will reflect cues to the loss of commitment and investment from a man.

Recent studies provide powerful support. Consider this question:

What would upset or distress you more: (a) imagining your mate having sexual intercourse with someone else, or (b) imagining your mate forming a deep emotional attachment to someone else?

The overwhelming majority (85%) of women to whom this dilemma was posed endorsed the second choice; most men (60%) endorsed the first. These sex differences were also observed in physiological arousal in response to imagining the two scenarios. In measures of heart rate, electrodermal activity, and *corrugator* contraction (frowning), men showed greater physiological arousal to imagined sexual infidelity than to emotional infidelity. Women, in contrast, tended to show more physiological arousal to imagined emotional infidelity than to sexual infidelity.⁹

In addition to species-typical and sex-differentiated features, however, jealousy exhibits within-sex variability. For example, in the study just described, although some 60% of the men reported that they would be more distressed by their partner's sexual infidelity, the other 40% reported that they would be more distressed by their partner's emotional

infidelity. These individual differences provide an important avenue for testing evolutionary psychological hypotheses. One such hypothesis is that relevant developmental experiences must occur before the mechanism is activated. In the case of men, the relevant experience might be a committed sexual relationship. In the current study, the majority of men who had not experienced such a relationship reported that they would be more upset by emotional, rather than sexual, infidelity. In contrast, most men who had experienced a committed sexual relationship reported that they would be more upset by sexual infidelity. Individual differences within men seem to be due, in part, to differing developmental experiences—in this case, whether or not the relevant activating context had been experienced.

These studies are clearly just the start of the exploration of this important psychological mechanism. Additional questions currently being explored include these: Does male sexual jealousy vary in intensity across cultures according to the magnitude of male parental investment typical for each culture? Does female jealousy decrease as a function of decreases in a partner's ability to provide resources? Does male sexual jealousy decrease as the reproductive value of his partner decreases? Is the partner who is relatively lower in perceived desirability more jealous than the partner who is higher in perceived desirability? All of these questions were guided by evolutionary psychological thinking, and answers to them over the next few years should provide an even greater understanding of the workings of this complex mechanism.

This analysis of jealousy is just one example of the heuristic and predictive value of evolutionary psychology. The analysis illustrates several progressive shifts in evolutionary thinking over the past few

years—the importance of numerous complex psychological mechanisms sensitive to specific features of the environment; the importance of historical, developmental, and situational contexts; and the importance of differences and similarities across genders, across cultures, and across individuals.

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Development as a Dynamic System

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The goal of the study of development is to understand how organisms change over time. What are the processes and mechanisms that allow humans and other animals to acquire complex, adaptive, stable behavior? What are the origins of perception, action, and thought? By what agents do organisms lose one behavior and replace it with another, for example, as in the transition from sucking to independent feeding or from crawling to walking?

To answer such developmental questions, researchers must study the ontogeny of particular behavioral systems such as feeding, locomotion, visual perception, language, or social attachment. The result is that developmental psychology is a field rich with data and theories specific to particular domains of development. The theories of Jean Piaget, Eleanor J. Gibson, and John Bowlby, for example, address how children come to think, perceive, and become attached to their families. We also have detailed knowledge, for instance, about the developmental psychobiology of independent feeding, locomotion, and social relations

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in nonhuman animals. With rare exceptions, however, theory and empirical inquiry do not cross species and domains of interest.

But can we discover qualities of development itself that transcend the particulars of cognition, perception, and social behavior? Are there general principles of developmental change that apply to all species and without specific regard to what behavior is developing? And, if such principles can be found, will they be overly general, or will they be useful for guiding and interpreting empirical studies?

Recently, developmentalists have turned toward the now burgeoning field of nonlinear dynamics (sometimes called chaos theory) for insight into general developmental process. Social scientists are joining a growing group of mathematicians, physicists, and biologists who are intrigued with complex systems that change over time, and especially with the remarkable properties of such systems to self-organize. (Self-organization here means the emergence of often intricate patterns from the relations among simple parts and without the need for prior programs or blueprints.) The excitement over dynamic systems has been fueled by James Gleick's best-seller, *Chaos*, as well as by widespread media coverage. Although one may be justifiably suspect of trendy science, I believe dynamic principles will have lasting value in developmental science.

THE CHALLENGES FOR A NEW PARADIGM

Dynamic principles are attractive because they address many longstanding puzzles that are common to the specific domains of developmental study. Fundamental is the question of origins: Where do new behavioral forms come from? As infants take their first steps, say their first words, or first discover hidden objects, they perform entirely new acts. Yet these novel behaviors, like the origins of new species in evolution, must arise from existing structures and capabilities. One currently fashionable solution to the problem of origins is to claim that new behaviors are not really novel at all, but are revelations of abilities that have been there all along. These abilities take the form of "innate knowledge" about physical properties of objects or species-specific "acquisition devices" that enable human offspring to acquire language and other skills. Such constructs allow developmentalists to finesse the question of ontogenetic origins by passing it off to the evolutionists, and thereby sidestep the hard issues of developmental process and mechanism. And while no contemporary developmentalist would eschew the importance of experience, the role of experience vis-à-vis so-called biological constraints in generating new forms is not well specified.

A second, recurrent problem in developmental study is what to make of variability, which takes two forms: variability in the same individual in different contexts and variability among different individuals'

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