aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Current Directions in Psychological Science
2014, Vol. 23(2) 115–120

DOI: 10.1177/0963721414521631
cdps.sagepub.com
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The Co-Evolution of Concepts and Motivation

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Abstract
Does the human mind contain evolved concepts? Many psychologists have doubted this or have investigated only a narrow set of concepts (e.g., object, number, cause). Does the human mind contain evolved motivational systems? Many more assent to this claim, holding that there are evolved motivational systems for, among other tasks, social affiliation, aggressive competition, and avoiding predation. An emerging research program, however, reveals that these are not separate questions. Any evolved motivational system needs a wealth of conceptual structures that tether the motivations to real-world entities. For instance, what use is a fear of predators without knowing what predators are and how to respond to them effectively? As we illustrate with case studies of cooperation and conflict, there is no motivation without representation: To generate adaptive behavior, motivational systems must be interwoven with the concepts required to support them and cannot be understood without explicit reference to those concepts.

Keywords
evolutionary psychology, concepts, motivation, free rider, formidability

"Hearing police sirens in the distance, Jake grabbed his friend and ran from the bar—Jake hadn't thrown the first punch or smashed that jukebox, but there was already a warrant out for his arrest." This sentence coordinates at least 20 concepts. Many of them—bars and jukeboxes, police and warrants—are clearly a product of our particular historical and cultural milieu; they have only ever been entertained by human minds in certain times and places. But other concepts—objects and causation, friends and fights—are likely to be evolved features of human nature, concepts that reliably develop in the absence of any particular idiosyncratic experiences.

Starting with the rationalist tradition of Descartes and Kant, philosophers and cognitive scientists have debated whether evolved, reliably developing (i.e., *innate*) concepts exist (see Tooby, Cosmides, & Barrett, 2005, for a modern and evolutionarily informed discussion of innateness). Just as all normally developing human bodies have common evolved anatomical structures, including eyes, hearts, and hands, do all human minds share a common psychological architecture including a variety of rich, contentful concepts? There is now extensive evidence consistent with this hypothesis (Carey, 2009; Pinker, 2007). Given its philosophical and mathematical roots, however, the research tradition mapping innate (i.e. evolved and reliably developing) concepts has focused mostly on a small set of concepts: time, space, object, number, cause, and basic psychological states such as beliefs and desires. The complementary research program that we review here instead takes evolutionary biology as its starting point.

Although both approaches emphasize that the mind has reliably developing evolved content, an evolutionary-psychological approach begins by considering the kinds of problems that human ancestors had to solve to successfully survive and reproduce. By combining this task analysis with cognitive and computational approaches for studying the mind, evolutionary psychologists have

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investigated a wide array of evolved concepts and have shown how these concepts underlie and enable motivation. Philosophical and biological approaches are mutually consistent and reinforcing; they simply start with different source domains to generate hypotheses for empirical exploration. We first describe the theoretical background of this new research program and then review illustrative examples from the domains that we have studied most: cooperation and conflict.

No Motivation Without Representation

What motivates people? Much research in psychology has examined broad, global, and often dichotomous theories of motivation. For instance, psychologists have hypothesized that people have motivations to approach some ends and to avoid others (Elliot, 2008) and that our motivational systems focus us on promoting some outcomes and preventing others (Higgins, 1998). Although inarguably fruitful, these approaches have missed a wealth of specialized, content-rich motivational systems. Recent research in evolutionary psychology suggests that the human mind has motivational systems for establishing friendships and mateships, coordinating group alliances and cooperation, and prevailing in conflict (Kenrick, Neuberg, Griskevicius, Becker, & Schaller, 2010).

There are powerful theoretical reasons to believe that systems of motivation could not have evolved—could not function—without being linked to evolved concepts (Tooby et al., 2005). Consider a motive to avoid predators—a useful motive for our hunter-gatherer ancestors (Barrett, 2005). Without a concept of predator, how could a person avoid being preyed upon? An untethered motive would not know how to tell dangerous animals from benign ones, or make the correct inferences about a predator's behavior to avoid becoming dinner. The successful functioning of a motive to avoid predation requires a complex and rich predator concept. An evolved concept like this is more than a simple detection system (i.e., it does not respond in a stereotyped way to a simple eliciting stimulus: What counts as a predator? And when you encounter one, do you freeze or flee, scream or stay quiet?). Conceptual and empirical analysis suggests that a predator concept would be quite complex (Barrett, 2005). Like other evolved concepts, it should have, among other components, (a) subcomponents that calibrate it based on personally or socially acquired information (i.e., learning; see Barrett & Broesch, 2012), (b) developmental changes that are calibrated to the functional demands of different life stages or sexes (e.g., calibration to the greater vulnerability one experiences as a child), (c) moderating conditions that calibrate it in response to evolutionarily recurrent life circumstances (e.g., greater vigilance when one is injured), and (d) calibrations based on relevant exogenous factors (e.g., different inferences depending on whether a predator appears temporarily sated).

Natural selection should craft content-rich, integrated sets of concepts and motivations for at least three reasons. First and foremost, the design criteria used by evolution—specifically, successful genetic replication—is irrational from an individual's perspective and simply cannot be derived logically. David Hume's (1739/2000) well-known barrier between "is" and "ought" prevents logical systems—on their own—from ever learning any value or motive, let alone the specific goal states needed for solving ancestral problems. In other words, values are not objectively present in the world and thus cannot be learned; they must be supplied by evolved motivational systems (Tooby et al., 2005). Second, learning through trial and error with a predetermined goal, although possible, is often costly. For instance, if an organism ingests a poison and dies, it cannot learn from this mistake. Thus, evolved motivational and conceptual systems with rich content can give organisms a leg up in solving these problems. Third, solutions to other biological problems require inferences about unobservable entities. For instance, another person's beliefs and desires cannot be seen, touched, or heard. If they cannot be perceived, data-driven learning processes cannot use them. Natural selection, however, can create minds that go beyond the information given and assume the existence of these unobservable entities (Cosmides & Tooby, 2013).

A Free-Rider Concept

Rivaled only by the eusocial insects, humans cooperate in groups in zoologically unprecedented ways. For instance, human groups share resources widely. This sharing allows people who are suffering from illness, injury, or plain bad luck to survive when they would likely perish (Gurven, 2004). Sustaining group cooperation and sharing, however, is not trivial. Among many challenges, it requires preventing exploitation by free riders—people motivated to take collective benefits without helping to create them. Unchecked, free riders destroy cooperation over evolutionary timescales, and often during the life of any particular cooperative endeavor. Evolutionary studies show that free riders must be identified and their behavior changed so that they either contribute to the collective good or are prevented from taking its benefits (Sasaki & Uchida, 2013).

Given this adaptive problem, one would expect the mind to have an evolved concept of free rider. This concept would allow one to (a) identify those people in the world who are free riders and (b) link this to judgments of right and wrong and to motivations to punish or exclude. Thus, a free-rider concept would be an evolved moral concept—a very specialized moral concept.

Table 1. Candidate Concepts With Evolved Structure

Cooperator (Delton & Robertson, 2012)
Free rider (Delton, Cosmides, Guemo, Robertson, & Tooby, 2012; Delton, Nemirow, Robertson, Cimino, & Cosmides, 2013)
Newcomer to a coalition (Cimino & Delton, 2010; Delton & Cimino, 2010)
Moral judgment (Hamlin, Wynn, & Bloom, 2007; van Leeuwen, Park, & Penton-Voak, 2012)
Dominance hierarchy (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011)
Ownership (Boyer, in press)
Ethnolinguistic categories (Moya, 2013)
Kinship (Lieberman, Oum, & Kurzban, 2008)
In-groups/out-groups (Miller, Maner, & Becker, 2010)
Romantic partners and rivals (Maner, Gailliot, Rouby, & Miller, 2007)
Entitlement (Petersen, Sell, Tooby, & Cosmides, 2012; Sell, Tooby, & Cosmides, 2009)
Disrespect (Sell, 2011b)
Physical formidability (Sell et al., 2010; Sell, Cosmides, et al., 2009)
Weaponry (Fessler, Holbrook, & Snyder, 2012)

Note: This table lists candidate concepts with evolved conceptual structure. Some candidates listed here have a stronger empirical basis than others. This list is meant to be illustrative, not exhaustive. The references provide further details on these concepts.

Human cooperation evolved in uncertain environments; even well-meaning cooperators would sometimes fail to contribute to a group. Thus, an evolved free-rider concept would need to make reference to unobservable mental states (e.g., a desire to exploit collective benefits), not simply observed contributions. Otherwise, well-meaning cooperators who happen to fail at contributing would also be classed as free riders. Although using unobservable mental states is difficult or impossible for data-driven learning mechanisms, natural selection can craft psychologies that go beyond the data. In a series of experiments, we have shown this to be true of free-rider identification (Delton, Cosmides, Guemo, Robertson, & Tooby, 2012). We exposed people to a hypothetical group-cooperation scenario wherein we manipulated the members' motivations while holding their objective contributions constant—specifically, putative free riders were depicted as motivated to exploit collective benefits. We then measured what categories people formed and the downstream motivational consequences of those categories. Consistent with our predictions, free riders were categorized separately from cooperators (despite the two groups' equal contributions), which in turn led to moralistic responses.

In other tests, we directly showed that data-driven approaches (e.g., reinforcement learning) cannot account for free-rider identification. First, in one study, we manipulated the observable, quantifiable contributions group members made; despite differing in contributions, however, all were well-meaning cooperators. Although people encoded this difference and viewed those with smaller contributions as less competent, it did not lead them to make moralistic responses. In other words, simply contributing less did not lead to categorization as a free rider. Second, another study showed that the mind will not encode just any statistical difference in a cooperative setting. When well-meaning cooperators varied in ways irrelevant to group cooperation, people did not encode this difference. Data-driven approaches, such as reinforcement learning and statistical pattern recognition, cannot account for the free-rider concept because it depends on an unobservable construct: the contributor's intentions.

But could these data be accounted for by a more general moral psychology? Indeed, research shows that the mind has reliably developing concepts related to general immorality (Hamlin, Wynn, & Bloom, 2007; van Leeuwen, Park, & Penton-Voak, 2012). Does the mind also have a specialized free-rider concept? Yes: When free riders are contrasted with other moral violators, they continued to be categorized as a separate type. This includes contrasting free riding with a very similar moral violation: stealing a resource communally owned by the group. Although both free riders and thieves have, in a sense, abrogated resources that the group is entitled to, these two different moral violations are nonetheless distinguished (Delton et al., 2012).

The free-rider concept coordinates identification procedures for determining who is a free rider with motivations to engage in exclusion or moralistic punishment (see also Delton, Nemirow, Robertson, Cimino, & Cosmides, 2013). This is but one example of the intimate connection between concepts and motivation; Table 1 lists a variety of other candidate concepts for sustaining human social relationships. As with the free-rider concept, these other concepts appear to have an evolved structure, not one that could be induced by more general learning abilities.

A Formidability Concept

Because animals often use aggression to win conflicts of interest, such as conflicts over food or territory, they are often equipped with mechanisms that enable them to

fight efficiently. For example, evolution has selected morphological features that aid many animal species in aggression, such as fangs, horns, claws, poisons, bludgeoning appendages, and muscular adaptations to choke, rend, crush, or otherwise incapacitate rivals. These are complemented by perceptual and behavioral adaptations that lead animals to target vulnerable parts of their adversaries (as exemplified by, e.g., throat ripping by wolves and wild dogs). Combat design is widespread in the animal kingdom (Huntingford & Turner, 1987).

Combat can be costly. Often, the reproductively advantageous choice is to cede a resource to an opponent rather than sustain grievous bodily injury in a losing battle. Even if a data-driven learning mechanism could develop concepts related to conflict and aggression, these would be costly lessons to learn. Natural selection would instead design animal minds that embody these facts and prudently avoid costly aggression. Indeed, many animal species have evolved mechanisms that allow them to estimate the costs of fighting by predicting (a) their opponent's fighting ability, (b) their own fighting ability, and (c) the benefits of winning.

Our research demonstrates that humans have all of these same features, many of them accomplished with specialized concepts that underlie the motive to succeed in conflicts. Humans, particularly males, have evidence of combat design in their perceptual, respiratory, circulatory, and musculoskeletal systems (Sell, Hone, & Pound, 2012). Beyond these, the minds of both men and women appear to come equipped with concepts that enable efficient resolution of conflicts. Chief among these is a concept of formidability, which appears in infancy (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011) and is supported by adaptations that enable humans to predict the fighting ability of others (particularly, and most accurately, of males). In one line of research, we showed that men and women could accurately assess the physical strength and fighting ability of males across cultures and language groups on the basis of photos of the males' faces or bodies (Sell, Cosmides, et al., 2009) and voice samples (Sell et al., 2010). Formidability is not, however, perceivable solely from simple sensory impressions. Instead, the mind's concept of formidability responds in complex ways to variables that ancestrally tracked the probability of victory; for example, when one is with a group of allies, one's rival is perceived to be less formidable (Fessler & Holbrook, 2013).

Like the concept of a free rider, formidability as a concept is tied to behavioral outputs. Men who feel more formidable are behaviorally distinct in ways that would have been reproductively advantageous in ancestral small-scale foraging environments. Just as with other animals, physically stronger men are more prone to anger and aggression, a finding that we and others have confirmed in samples from several cultures, including U.S. college students (Sell, Tooby, & Cosmides, 2009), foragers in the Central African Republic (Hess, Helfrecht, Hagen, Sell, & Hewlett, 2010), and East Indians (Archer & Thanzami, 2007). As one would predict based on the logic of animal conflict, stronger men are more outgoing (Lukaszewski, 2013), expect better treatment, and feel more entitled (Sell, Tooby, & Cosmides, 2009). Our research also shows that more formidable men hold self-beneficial attitudes about political issues—issues for which formidability could play no rational role in mass societies, but could have in small-scale ancestral ones. For example, strong rich men oppose income redistribution, but strong poor men favor it, a finding that has been replicated in three countries (Petersen, Sznycer, Sell, Tooby, & Cosmides, 2013).

If natural selection linked a person's sense of entitlement to their formidability, it follows that natural selection must have designed a concept that represents whether that person is being accorded appropriate respect (i.e., being "given their due"). Without this, a sense of entitlement would leave one unable to determine when to assert one's own interests. We suggest that the concept of disrespect evolved for this purpose and is functionally designed to track situations in which it would be advantageous to fight, argue, or otherwise bargain for better treatment (Sell, 2011b; for a related proposal, see McCullough, Kurzban, & Tabak, 2013). Like many other animals, humans are more likely to engage in conflict when they value the contest more than their rival does (e.g., when they "need" it more; Sell, 2011a). This is embodied in the concept of disrespect itself—for example, it is not disrespectful for someone to intentionally damage your coat to save their life, but it is extremely disrespectful for them to intentionally damage your coat to clean their shoes. Other indicators of disrespect, such as insults, follow similar adaptive logic (see Sell, 2011b).

Implications and Future Directions

There are many remaining questions for future work. First, as illustrated in Table 1, a variety of concepts remain to be explored. Some of these may upend traditional assumptions of what it means for something to be an evolved concept. For instance, the onset of puberty might cause the development of concepts related to mating (e.g., sexual jealousy). Although arising more than a decade after birth, these concepts would be no more or less designed by selection than concepts in the minds of 2-month-olds. In other words, evolved and reliably developing concepts need not be present at birth. Second, the mind might also contain evolved concept-generating systems (i.e., learning systems). For instance, humans can create a vast array of novel concepts for tools and artifacts (e.g., hammers, carburetors, flash drives) based on their design function; nonetheless, the system that

generates these concepts is a reliably developing evolved system (German & Barrett, 2005).

Regardless of how data answer these questions, this approach can help reframe longstanding debates about the nature of concepts. In past approaches, researchers have debated whether definitions, prototype structure, or the use of exemplars form the core of concepts (see Margolis & Laurence, 1999). But there need be no single correct answer to this question. Instead, the problem that a concept is designed to solve will determine how it is organized—form may follow from function (Boyer, in press). This understanding has the potential to revolutionize areas of psychology that have traditionally been understood without reference to evolved function. For example, attribution theorists would benefit from the understanding that our causal-reasoning systems evolved to maximize our control of the future, not to provide us with a philosophically sound understanding of the past. Motivational theorists would also benefit from recognizing that "drives," "instincts," and "desires" are part of complex computational systems that respond to information and do not work at odds with reasoning—in fact, they enable it.

We contend that the study of concepts must be done in parallel with motivational psychology. That concepts exist because they (or the systems that generated them) were designed by natural selection to serve a purpose is an indispensable fact. Just as the concepts of free rider and formidability exist as integrated components of complex motivational systems, so too might concepts such as kin, cooperator, friend, mate, predator, formidability, kindness, cruelty, healthy, and many others.

Recommended Reading

Carey, S. (2009). (See References). A comprehensive review of theory and research on reliably developing concepts and related issues.

Cosmides, L., & Tooby, J. (2013). (See References). Discusses the relationship among evolution, cognition, and motivation in greater depth than the current paper.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

This research was supported by a National Institutes of Health Director's Pioneer Award to Leda Cosmides, National Science Foundation Grant #0951597 to Leda Cosmides and John Tooby, and a grant from the John Templeton Foundation. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the National Institutes of Health, the National Science Foundation, or the John Templeton Foundation.

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