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The Evolution of Concepts About Agents

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We now know that the mind of a human infant is neither a blank slate nor, in William James's words, "one great blooming, buzzing confusion" (1890, p. 462). Instead, infants are born with what Carey (2009) has called "a set of innate, representational primitives" that "get learning off the ground" and "guide an infant's expectations of which objects go together and how they are likely to behave." Armed with these concepts, infants begin life with several "core" systems of knowledge, each specialized for representing and reasoning about entities of different kinds (Carey & Spelke, 1996). Three core systems have been widely discussed: one that deals with the causal and spatial relations among objects, another that concerns number, and a third that deals with agents, including their goals, attentional states, and the causal mechanisms that underlie their behavior.

How did conceptual thinking evolve? What advantages did it bring? Here we consider the evolution of conceptual knowledge about agents. We argue that the origin of human concepts of agents can be found in the predisposition of monkeys, apes, and perhaps many other animals to recognize members of their own species as individuals and group them into categories based on their behavior. In primates, conceptual thinking about agents has evolved because it helps individuals form stable, adaptive social relationships.

Social knowledge in animals is of particular interest because, unlike the recognition of quantities and objects (now the most widely cited examples of conceptual thinking in animals), it involves the recognition and classification of animate creatures according to behavior. It therefore includes implicit theories about motivation and action.

INDIVIDUAL RECOGNITION

Individual recognition is widespread in animals (Tibbetts & Dale, 2007). Many species have specialized brain cells that respond particularly strongly to faces (Leopold & Rhodes, 2010),

voices (Petkov et al., 2008), and familiar speakers (Belin & Zattore, 2003). Although individual recognition has most often been documented in the auditory mode through playback experiments (e.g., Rendall, Rodman, & Emond, 1996), subjects in these experiments often seem to be engaged in more complex cross-modal or even multimodal processing. A baboon who looks toward the source of the sound when she hears her offspring's call (Cheney & Seyfarth, 2007) acts as if the sound has created an expectation of what she will see if she looks in that direction. Dogs (Adachi, Kuwahata, & Fujita, 2007) and squirrel monkeys (Adachi & Fujita, 2007) associate the faces and voices of their caretakers, rhesus macaques integrate the faces and voices of conspecifics (Sliwa, Duhamel, Pascalis, & Wirth, 2011), and horses associate the whinny of a specific herd member with the sight of that individual (Proops, McComb, & Reby, 2008). Such cross-modal integration is not surprising, given the extensive connections between auditory and visual areas in mammalian brains (Cappe & Barone, 2005). Humans, of course, routinely integrate the perception of faces and voices to form the rich, multimodal concept of a person (Campanella & Belin, 2007).

How do animals learn to recognize individuals? Obviously, recognition cannot be entirely innate: Animals require experience to recognize the members of their group and any new animals who join it. Such learning almost certainly begins with the formation of classical, Pavlovian associations. Neural structures specialized for the recognition of faces, voices, and their cross-modal integration, however, suggest that many animals have an innate predisposition to organize what they have learned into concepts: in this case, the concept of a specific individual. These concepts cannot be reduced to or defined by any single sensory attribute but involve, instead, the integration of many different attributes into a single percept, such that the sound of a specific individual's voice

creates an expectation of what one will see and the sight of that individual creates an expectation of what one will hear. Such concepts are implicit and, needless to say, formed without language: Animals do not, as far as we know, give names to each other. But they are concepts, nonetheless, and they are widespread in the animal kingdom. Perhaps the earliest concept was a social one—what in our species we call the concept of a person.

OTHER SOCIAL CLASSIFICATIONS

Many animals not only recognize individuals but also classify them into groups, organizing them according to close social bonds, linear dominance ranks, and transient sexual relations. Like the recognition of individuals, these classifications appear to involve the formation of concepts. Baboons provide some good examples.

Baboons live throughout Africa in groups of 50 to 150 individuals. Males and females have very different life histories. When they reach adult size, at 6 to 9 years of age, males leave the group where they were born and emigrate to other groups. Females, in contrast, remain in their natal group throughout their lives, maintaining close bonds with their matrilineal kin through frequent grooming, mutual support in coalitions, tolerance at feeding sites, and interactions with each other's infants (Cheney & Seyfarth, 2007; Silk et al., 2010a). Adult females can also be ranked in a stable, linear dominance hierarchy that determines priority of access to resources. From birth, daughters acquire ranks immediately below those of their mothers. As a result, the stable core of a baboon group consists of a hierarchy of matrilines, in which all members of, say, matriline B outrank or are outranked by all members of matrilines C and A, respectively. Rank relations are generally stable over time, with few reversals occurring either within or between families. When reversals do occur, however, their consequences differ significantly depending on who is involved. If the third-ranking female in matriline B (B3) rises in rank above her second-ranking sister (B2), the reversal affects only these individuals; the B family's rank relative to other families remains unchanged. However, a rank reversal between females from different matrilines (for example, C1 rising in rank above B3) usually causes all members of matriline C to rise above all members of matriline B (Cheney & Seyfarth, 1990, 2007). The ranked, matrilineal society of baboons is typical of many Old World monkeys.

Baboons, then, are born into a social world that is filled with statistical regularities: Animals interact in highly predictable ways. A young baboon quickly learns to recognize these patterns. By the time she is an adult, she recognizes both the close bonds among matrilineal kin and the linear rank relations within and between families (Cheney & Seyfarth, 2007). She also appears to recognize other animals' motives and the causal relations that govern their interactions; she knows, for example, when another individual is vocalizing *to her* (Engh, Hoffmeier, Cheney, & Seyfarth, 2006), and when an animal's grunt signals reconciliation after a fight (Cheney & Seyfarth, 1997; Wittig, Crockford, Wikberg, Seyfarth, & Cheney, 2007a). Does her knowledge of kin and rank relations involve the formation of concepts? Does her knowledge of motives and causality constitute a rudimentary theory of social life?

ALTERNATIVE HYPOTHESES

One hypothesis argues that memory and classical conditioning are entirely sufficient to explain primates' social knowledge. As they mature, baboons recognize patterns of behavior that link individuals in predictable ways. Their knowledge cannot be described as conceptual because there is no direct evidence for the existence of such concepts, and social knowledge can just as easily be explained by simpler hypotheses based on learned associations and prodigious memory (e.g., Schusterman & Kastak, 1998).

Explanations based on memory and associative learning are powerful and appealing under simplified laboratory conditions, but they strain credulity when applied to behavior in nature, where animals confront more complex sets of stimuli. A young baboon, for example, must learn thousands of dyadic (and tens of thousands of triadic) relations in order to predict other animals' behavior. The magnitude of the problem makes one wonder whether simple associations, even coupled with prodigious memory, are equal to the task. Faced with the problem of memorizing a huge, ever-changing dataset, humans are predisposed to search for a higher order rule that makes the task easier (Macuda & Roberts, 1995). Why should baboons be any different?

In fact, several observations suggest that baboons' social knowledge is organized into units of thought that resemble our concepts. To begin, consider the speed of their reactions to events. When baboons hear a sequence of vocalizations that violates the dominance hierarchy, they

respond within seconds (Cheney & Seyfarth, 2007). When a male macaque, involved in a fight, tries to recruit an ally, he seems instantly to know which individuals would be the most effective partners (Silk, 1999). The speed of these reactions suggests that animals are not searching through a massive, unstructured database of associations but have instead—as a kind of cognitive shortcut—organized their knowledge into concepts: what we call dominance hierarchies and matrilineal (family) groups.

Social categories qualify as concepts because they cannot be reduced to any one, or even a few, sensory attributes. Family members do not look alike, sound alike, or share any other physical features that make them easy to tell apart. Infants are black whereas juveniles are olive brown, males are larger than females, and many individuals have idiosyncratic wounds or postures, yet none of this variation affects other animals' classifications: A three-legged member of family X is still a member of family X.

Nor is the classification of individuals into family groups based on behavior. The members of high-ranking families are not necessarily more aggressive than others, do not range in separate areas or groom or play together more often. In fact, because mothers generally groom daughters more than sons, grooming within families can be highly variable—yet this has no effect on other animals' perception of who belongs in which family.

Social categories, moreover, persist despite changes in their composition. Among females and juveniles, the recognition of families is unaffected by births and deaths; among adult males, the recognition of a linear, transitive hierarchy persists despite frequent changes in the individuals who occupy each rank. In the mind of a baboon, social categories exist independent of their members.

The classification of individuals into families seems to occur not because outsiders treat family members as identical, but because outsiders regard the family as an assemblage of different individuals who share a common attribute. While the individuals within a family can sometimes be substituted for one another—one member of the A matriline, for example, can reconcile “on behalf of” another (Wittig et al., 2007a)—they nonetheless retain their distinct identities. In this respect, baboons appear to be “psychological essentialists” (Medin, 1989): They act as if each animal, though a distinct individual, has an “essence or underlying nature” (Gelman, 2003) that makes her a member

of family X. The same essentialist thinking applies to each family.

Finally, the classification of individuals into families and their arrangement into a dominance hierarchy are cognitive operations that affect behavior. When listeners hear vocalizations from two individuals interacting elsewhere, their response depends not just upon the animals' identities but also upon their ranks and family membership (Bergman, Beehner, Seyfarth, & Cheney, 2003). Social categories are units of thought that determine how individuals behave.

Bound up in the baboons' concepts are expectations: If a member of the A family threatens the member of another matriline, listeners expect that other family members will come to the threatener's aid (Wittig et al., 2007b). Baboons' concepts thus concern not only which entities “go together” but also how category membership affects behavior. Indeed, the baboons' concepts and their expectations about behavior are intimately entwined: They use their observations of behavior to create concepts and, having done so, use their concepts to predict behavior. For baboons, it is difficult if not impossible to separate concepts from the theory-like relations that underlie them.

Long-term data show that female baboons with the strongest social bonds experience less stress, have higher infant survival, and live longer than others (Silk et al., 2009, 2010b; Wittig et al., 2008). We propose that the ability to form concepts helps an individual both to monitor other animals' relations and to form relationships of her own. For these reasons natural selection has favored the evolution of conceptual thinking about individuals, their motives, and their relationships.


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