

The Evolution of Social Categories

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Abstract A widely accepted view holds that human infants' knowledge of the world develops not from a single, general-purpose ability to reason about objects and events but instead from several "core" systems of knowledge, each specialized for representing and reasoning about entities of different kinds. One functionally specialized system concerns knowledge about animate creatures. If knowledge about animate beings – particularly conspecifics – constitutes a core system of cognition in human infants, it may be possible to explain its evolution by 1) identifying a core system of social knowledge in nonhuman primates and other animals, 2) demonstrating that this knowledge constitutes a functionally specialized system and 3) demonstrating that knowledge of other individuals' identities, category membership, and motives is adaptive, contributing to the reproductive success of individuals. Here we test these predictions using data from wild baboons. Results indicate that baboons classify each other along a number of dimensions simultaneously: as individuals, members of matrilineal kin groups, holders of specific dominance ranks, and participants in more transient social relationships. Their formation of social categories is based on certain expectations and assumptions of causality. Baboon social knowledge, moreover, is adaptive because it allows individuals to form relationships that reduce stress and increase reproductive success.

1 Introduction

A widely accepted view holds that human infants' knowledge of the world develops not from a single, general purpose ability to reason about objects and events but instead from several "core" systems of knowledge, each specialized for representing and reasoning about entities of different kinds (Hirschfeld and Gelman 1994; Carey and Spelke 1996). This view of mental function as a collection of domain-specific

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“modules” (Fodor 1983) or functional specializations (Barrett and Kurzban 2006) comes in many different forms. The more extreme proponents of the modular view (e.g., Cosmides and Tooby 1994) write as if general learning processes like classical and instrumental conditioning, which obey similar rules across many different domains, have no place in the explanation of human behavior. Others willingly accept that general modes of conditioning can operate within a domain, and experience of a general sort can in some cases lead to domain-specific expertise (Gallistel et al. 1991; Shettleworth 1998). Studies of language acquisition in children offer an excellent example of research in which there is an active debate about the relative importance of generalized and specialized learning mechanisms (compare Jackendoff 1994 and Pinker 1994 with Tomasello 2003). Regardless of their stance on the relative importance of domain-specific and domain-general processes, however, all investigators agree that it can be difficult to establish precisely the borders of a cognitive “domain.”

Theories of domain-specific knowledge are evolutionary theories: they assume that our cognitive “architecture” takes the form that it does because, during the evolutionary history of humans, other primates, and perhaps other birds and mammals, one style of perception and cognition has given individuals an advantage in survival or reproduction over others who perceive the world in a different way (Barkow et al. 1992). Supporting this view, domain-specific hypotheses receive considerable support from the ethological literature. For example, in her review of animal learning and behavior, Shettleworth concludes: “Our review of how animals perceive, . . . learn, . . . recognize, and categorize, . . . makes clear that the animal mind contains a variety of adaptively specialized cognitive modules” (1998, p. 566). As in studies of infant development, the many candidates for separate cognitive modules in animals “are distinguished from one another by domain, representational content, and possible distinctive rules of operation.” This is not to say, however, that the animal mind is exclusively modular, because domain-specific processing can coexist with associative processes that obey the same general rules across many sensory modalities and behavioral contexts. As Shettleworth puts it, “associative learning has a variety of adaptive uses” (1998, p. 568).

Knowledge of animate creatures, or “agents,” is often cited as one of the human infant’s core systems of knowledge. Studies supporting this view have examined infants’ and children’s knowledge of animate and inanimate objects (Gelman et al. 1983), their early recognition of faces and voices (e.g., Kleiner 1993; Vouloumanos and Werker 2007), biological classification (Keil 1989), and attribution to others of mental states like knowledge, motives, and beliefs (e.g., Leslie 1987; Wellman 1990), as well as adults’ organization of individuals into social categories (e.g., Atran 1990; Hirschfeld 1994). Taken together, these studies suggest that children are born with an innate, domain-specific sensitivity to animate as opposed to inanimate objects, and within the former group to humans as opposed to other creatures. From these early perceptual and cognitive specializations, infants and children rapidly develop concepts and theories about people as unique individuals who can be classified into certain social categories or groups and whose behavior is closely linked to their mental states.

If knowledge about animate beings – particularly conspecifics – constitutes a core systems of cognition in human infants, it may be possible to explain its evolution by 1) identifying a core system of social knowledge and classification in nonhuman primates and other animals, 2) demonstrating that this knowledge involves domain-specific, functionally specialized processing, and 3) demonstrating that knowledge of others' identities, category membership, and motives is adaptive, contributing to individuals' reproductive success. In this paper we begin with a brief review of the brain areas in primates that appear to be specialized for processing social stimuli. We then review what is known about the social knowledge of one primate species, the baboon (*Papio cynocephalus ursinus*), and consider its adaptive value. We then discuss whether baboon social knowledge constitutes an innate, domain-specific specialization and whether it involves the construction of concepts or theories. We conclude with some speculations about the primacy of social categories during the course of primate and human evolution.

2 Neural Correlates of Social Knowledge

Monkeys have “face cells” in the temporal cortex that respond at least twice as vigorously to faces or components of faces (like eyes or mouths) than to other complex visual stimuli (Tsao et al. 2003, 2006). Face cells are surprisingly specialized. Those in the inferior temporal cortex (IT) seem most important for processing facial identity, whereas those in the superior temporal sulcus (STS) seem most important for processing facial expressions. IT and STS are extensively interconnected and probably share face-specific information (Weiss et al. 2002; Ghazanfar and Santos 2004). Face cells in STS respond not only to facial expressions but also to the direction of an individual's head orientation and gaze. Their response is greatest when head orientation and gaze direction are congruent, less strong when they are incongruent (Emery and Perrett 2000; Jellema et al. 2000; Perrett et al. 1992; Eifuku et al. 2004). The STS of rhesus macaques also includes neurons that fire when the monkey observes an individual walking, turning his head, bending, or extending his arm (Perrett et al. 1990).

Particularly intriguing are the “mirror-neurons” in the inferior parietal lobule that show elevated activity both when the subject monkey executes a specific grasping action and when the monkey observes a human or other monkey execute a more or less similar grasp (Rizzolatti and Craighero 2004). Neurons that code for specific acts, such as grasping, also seem to be context-dependent. Some neurons respond more when the monkey grasps a piece of food to eat it than when he grasps the same food to place it into a container. This same context-dependence is preserved when the monkey observes *another* individual perform these actions. Significantly, many neurons begin to fire *before* the other individual actually performs a specific action, that is, before he grasps-to-eat as opposed to grasps-to-place. Thus, it seems possible that these neurons encode not only the specific motor act but also the actor's

intentions (Fogassi et al. 2005; see also Nakahara and Miyashita 2005; Rizzolatti and Craighero 2004; Rizzolatti and Buccino 2005).

Finally, monkeys – like humans – process their own species' vocalizations in ways that are measurably different from the way they process other auditory stimuli. Like humans, monkeys display a left-brain, right-ear advantage when processing their own species' vocalizations, but not when processing other sounds (Petersen et al. 1978; Hefner and Hefner 1984; Weiss et al. 2002; Poremba et al. 2004; but contrast Hauser and Andersson 1994 with Teufel et al. 2007). The processing of conspecific vocal signals also has a strong bi-modal component. Monkeys recognize the correspondence between facial and vocal expressions (Ghazanfar and Logothetis 2003), and when rhesus macaques hear another monkey's calls, they exhibit neural activity not only in areas associated with auditory processing but also in higher-order visual areas (Gil da Costa et al. 2004).

Specialized cells and unique brain mechanisms for dealing with socially relevant stimuli are not definitive proof of domain-specific social intelligence in primates. But they are just what we would expect to find if natural selection had acted with particular force to favor individuals skilled in solving social problems (for further discussion, see Cheney and Seyfarth 2007).

3 Social Knowledge in Baboons

Baboons are Old World monkeys that shared a common ancestor with humans roughly 30 million years ago (Steiper et al. 2004). They live throughout the savannah woodlands of Africa in groups of 50 to 150 individuals. Although most males emigrate to other groups as young adults, females remain in their natal groups throughout their lives, maintaining close social bonds with their matrilineal kin (Silk et al. 1999, 2006a, b). Females can be ranked in a stable, linear dominance hierarchy that determines priority of access to resources. Daughters acquire ranks similar to those of their mothers. The stable core of a baboon group is therefore a hierarchy of matrilines, in which all members of one matriline (for example, matriline B) outrank or are outranked by all members of another (for example, matrilines C and A, respectively). Ranks within matrilines are as stable as those between matrilines: for example, A1 > A2 > A3 > B1 > B2 > C1, where letters are used to denote matrilineal kin groups and numbers denote the different individuals within them (Cheney and Seyfarth 2007).

Baboon vocalizations, like those of many other primates, are individually distinctive (e.g., Owren et al. 1997; Rendall 2003), and playback experiments have shown that listeners recognize the voices of others as the calls of specific individuals (reviewed in Cheney and Seyfarth 2007). The baboon vocal repertoire contains a number of acoustically graded signals, each of which is given in predictable contexts. Because calls are individually distinctive and each call type is predictably linked to a particular social context, baboon listeners can potentially acquire quite specific

information from the calls that they hear. Experiments that test what information actually is obtained are thus, in effect, tests of social cognition.

Throughout the day, baboons hear other group members giving vocalizations to each other. Some interactions involve aggressive competition, for example, when a higher-ranking animal gives a series of threat-grunts to a lower-ranking animal and the latter screams. Threat-grunts are aggressive vocalizations given by higher-ranking to lower-ranking individuals, whereas screams are submissive signals, given primarily by lower- to higher-ranking individuals. A threat-grunt-scream sequence, therefore, potentially provides information not only about the identities of the opponents involved but also about who is threatening whom. Baboons are sensitive to both types of information. In playback experiments, listeners respond with apparent surprise to sequences of calls that appear to violate the existing dominance hierarchy. Whereas they show little response upon hearing the sequence “B2 threat-grunts and C3 screams,” they respond strongly – by looking toward the source of the call – when they hear “C3 threat-grunts and B2 screams” (Cheney et al. 1995a). Between-family rank reversals (C3 threat-grunts and B2 screams) elicit a stronger violation of expectation response than do within-family rank reversals (C3 threat grunts and C1 screams; Bergman et al. 2003).

A baboon who ignores the sequence “B2 threat-grunts and C3 screams” but responds strongly when she hears “C3 threat-grunts and B2 screams” reveals, by her responses, that she recognizes the identities of both participants, their relative ranks, and their family membership. Baboons who react more strongly to call sequences that mimic a between-family rank than to those that mimic a within-family rank reversal act as if they classify individuals simultaneously according to both rank and kinship (Bergman et al. 2003). In all of these cases, listeners act as if they assume that the threat-grunt and scream have occurred together not by chance, but because one vocalization caused the other to occur. Without this assumption of causality there would be no violation of expectation when B2’s scream and C3’s threat-grunt occurred together.

Baboons’ ability to deduce a social narrative from a sequence of sounds reveals a rich cognitive system in which listeners extract a large number of complex, nuanced messages from a relatively small, finite number of signals. A baboon who understands that “B2 threat-grunts and C3 screams” is different from “C3 threat-grunts and B2 screams” can make the same judgment for all possible pairs of group members as well as any new individuals who may join (Cheney and Seyfarth 2007).

In addition to making judgments based on social causation, rank, and kinship, baboons appear to recognize other individuals’ intentions and motives. Baboon groups are noisy, tumultuous societies, and a baboon would not be able to feed, rest, or engage in social interactions if she responded to every call as if it were directed at her. In fact, baboons seem to use a variety of behavioral cues, including gaze direction, learned contingencies, and the memory of recent interactions with specific individuals when making inferences about the target of a vocalization. For example, when a female hears a recent opponent’s threat-grunts soon after fighting with her, she responds as if she assumes that the threat-grunt is directed at her, and she avoids the signaler. However, when she hears the same female’s threat-grunts soon after

grooming with her, she acts as if the calls are directed at someone else and ignores the calls (Engh et al. 2006a).

The attribution of motives to others is perhaps most evident in the case of “reconciliatory” vocalizations. Like many other group-living animals, baboons incur both costs and benefits from joining a group. In an apparent attempt to minimize the disruptive effects of within-group competition, many primates “reconcile” with one another by coming together, touching, hugging, or grooming after aggression (Cheney et al. 1995b). In baboons, reconciliation among females occurs after roughly 10% of all fights, and typically occurs when the dominant animal grunts to the subordinate (Cheney et al. 1995b; Silk et al. 1996). Playback experiments have shown that, even in the absence of any other behavior, grunts alone function to restore former opponents’ behavior to baseline levels. When a subordinate female hears her opponent’s grunt soon after a fight, she approaches her opponent and tolerates her opponent’s approaches at a rate that is even higher than baseline rates (Cheney and Seyfarth 1997). In contrast, hearing the grunt of another, previously uninvolved high-ranking female unrelated to her opponent has no effect on the subordinate’s behavior.

In some cases, the behavior of subordinates after aggression seems to involve more complex and indirect causal reasoning about both other animals’ motives and their kinship bonds. Playback experiments have shown that baboons will accept the “reconciliatory” grunt by a close relative of a recent opponent as a proxy for direct reconciliation by the opponent herself (Wittig et al. 2007). If individual D1 has been threatened by individual A1 and then hears a grunt from A2, in the hour that follows she is more likely to approach, and more likely to tolerate the approaches of, A1 and A2 than if she had heard no grunt or a grunt from another high-ranking individual unrelated to the A matriline. Intriguingly, D1’s behavior toward other members of the A matriline does not change. Subjects in these experiments act as if they recognize that a grunt from a particular female is causally related to a previous fight, but only if the caller is a close relative of her former opponent.

4 The Function of Social Cognition

Baboons live in a society where reproductive success depends upon social skills. Among female baboons living in Kenya, longevity and infant survival are the best predictors of reproductive success, and the best predictor of infant survival is the extent of a female’s social integration (Silk et al. 2003). Females are strongly motivated to form close social bonds (as measured by frequent proximity and grooming) with others, particularly their matrilineal kin. When a mother dies, females respond by strengthening their bonds with other matrilineal kin. When few or no matrilineal kin are available, they form bonds with paternal sisters and/or unrelated individuals (Silk et al. 2006a).

In our study, female longevity and infant survival are also the primary determinants of a female’s lifetime reproductive success (Cheney et al. 2004), and females experience the greatest stress from predation and infanticide – the two events that

exert the greatest effect on their own and their infants' survival and reproduction. When her infant is threatened with infanticide, a female can alleviate stress by forming a temporary pair bond, or "friendship" with an adult male; when a close companion is killed by a predator, she can alleviate stress by broadening and extending her network of bonds with other females (Beehner et al. 2005; Engh et al. 2006b, c). During a "calm" period without infanticide or predation, females whose grooming networks focused on a few preferred partners had lower baseline glucocorticoid levels than did females whose grooming was spread more widely among others (Crockford et al. 2008). When the same females were subsequently challenged by the threat of infanticide, individuals with the most focused grooming networks and the lowest baseline glucocorticoid levels showed the smallest increase. All females decreased their grooming diversity when challenged, and those who showed the greatest decrease in grooming diversity had the smallest increase in glucocorticoid levels (Wittig et al. 2008).

In sum, a female baboon's skill in forming and maintaining social relationships affects her ability to overcome stressful situations and, ultimately, her reproductive success. Under these conditions, an individual who seeks to form and maintain those social relationships that return the greatest benefit must know as much as possible about other animals' relations, that is, she must have a sophisticated understanding of the individuals in her group, their long-term associations, short-term bonds, and the motivation that underlies them. Natural selection has thus favored the evolution of skills in identifying and classifying conspecifics because these skills are essential to survival and reproduction (Cheney and Seyfarth 2007).

5 Defining the Domain

The baboons' social domain consists of other baboons. We draw this conclusion because individuals single out other baboons and respond to them in ways that differ from the way they respond to, for example, other animals, rocks, trees, or clouds. Baboons recognize others as individuals and attribute to their conspecifics properties that they do not attribute to other organisms. They also perform operations (or computations) on individual baboons that they do not perform on other species.

Baboons seem to recognize that many animals have the capacity for self-generated motion and are therefore different from inanimate objects. When walking among impala, elephants, and warthogs, for instance, they appear to anticipate these animals' behavior and avoid them (particularly elephants) if they approach. Baboons thus have a kind of ontological category *animal* that excludes immobile objects. Within this category, they may associate different vocalizations with different species (see Seyfarth and Cheney 1990; Hauser and Wrangham 1990; and Zuberbuhler 2002a, b for evidence of such recognition in various primates), but there is as yet no evidence that they make finer discriminations, for example by recognizing different individuals within a species.

In contrast, baboons respond to each other as *individuals*: they link specific faces and bodies with particular voices to form a percept that is independent of modality. When a baboon hears a grunt from Sylvia she forms an expectation that, if she looks toward the sound, Sylvia is whom she will see. Baboons further assume that each individual has *motives*; they assume, in other words, that under certain circumstances the individual will behave toward specific others in particular ways. If a female hears a juvenile's distress scream, she looks toward the juvenile's mother (Cheney and Seyfarth 1999); if she receives aggression from Sylvia and soon thereafter hear Sylvia's threat grunt, she assumes that the threat grunt is directed at her (Engh et al. 2006a).

Baboons also classify other baboons according to their place in the group. Such classification occurs along several different dimensions. An individual occupies a specific dominance rank, for example, and is grouped with other individuals in a particular matriline. These classifications have several interesting properties. First, the inclination to rank others occurs not just among females, whose ranks are stable for years, but also among males, whose ranks change often (Kitchen et al. 2005).

Second, classifications are not based on physical appearance. Higher-ranking animals are not older, larger, or different in any obvious way from lower-ranking animals, and as far as we can tell members of the same matriline do not look alike. From its first day of life, an infant baboon is associated with its matrilineal kin by others, even though, as an infant, it looks very different from these animals.

Third, classification is genuinely "nested:" although the members of a matriline are associated together, within this group they retain their individual identities. Kin-biased reconciliation provides a good example. If individual D1 receives aggression from A1 and then hears a grunt from an individual unrelated to A1, the grunt has no effect on D1's behavior. However, if the grunt comes from a member of A1's matriline (say, A2), it acts as a reconciliatory signal, changing D1's behavior toward A1 and A2 but not toward any other members of the A matriline (Wittig et al. 2007). D1 behaves as if she recognizes that members of the A family "go together" but nonetheless remain distinct individuals.

Fourth, classifications persist despite births, deaths, and other demographic changes. This property suggests that baboon social knowledge is to some degree abstract, because the social categories of rank and matrilineal kinship persist despite changes in the individuals who comprise them.

This level of recognition and classification may be unique to conspecifics. Although no experiments have been conducted, it seems reasonable to assume that baboons do not, for instance, distinguish one rock from another and place all rocks into the same general category, or distinguish among different individual giraffes. Plants that provide food may constitute an exception. Experiments by Menzel (1991), for example, suggest that Japanese macaques distinguish different species of trees and associate, for each species, its own specific leaves, fruit, and location.

The privileged status of one's own species is not fixed and immutable: extensive experience with another species may overcome an individual's tendency to treat the members of her own species differently from all others. In a classic experiment, Humphrey (1974) tested rhesus macaques' interest in pictures of conspecifics and

pictures of pigs. Without any training, subjects treated pictures of individual monkeys as different individuals but made no such distinction among pictures of individual pigs. However, after living for several weeks in a room where the wall was covered with pictures of different pigs, the same subjects responded to pictures of pigs in the same way that they responded to pictures of conspecifics – in both cases, distinguishing one individual from another. Hoesch (1961) describes a female baboon, Ahla, who was raised among goats on a farm in Namibia. As an adult, Ahla recognized individual goats by both their physical appearance and their voices. She also knew which kid was associated with each adult female. Ahla learned, in other words, to recognize in goats the same social categories that she would normally have recognized in baboons (Cheney and Seyfarth 2007).

Nonetheless, it seems unlikely that under normal circumstances baboons recognize and classify the members of other species in the same way that they recognize and classify other baboons. This is not surprising, because it is difficult to imagine how a baboon would benefit from recognizing, for example, different individual impala, or why natural selection would have favored this level of classification outside the social domain. If this conclusion is correct, then the borders of the baboons' social domain are clearly defined; for them, the "frame problem" is easily solved.

6 Is Primate Social Cognition Innate?

Thus far, all of our studies have examined adult subjects. As a result, we do not yet know whether the components of social intelligence – the recognition of others as individuals, the grouping of individuals according to rank and matrilineal kinship, and the "tracking" of transient relationships – constitute an innate property of the baboon's mind or are acquired only after extensive experience, through more general processes of perception, association, and memory.

Of course, even proponents of the most strongly innatist view must accept that some learning underlies baboons' social knowledge, because an infant baboon must learn the characteristics of the particular individuals that comprise her group. The question then becomes: is the infant baboon's mind a complete *tabula rasa*, ready to accept any social arrangement to which it might be exposed – monogamy, polygyny, with or without hierarchies or kin groups – or are infants born with an innate predisposition to recognize and classify individuals in some ways rather than others?

One hypothesis argues that baboons have an entirely unconstrained mind and that general learning mechanisms (classical and instrumental conditioning) are entirely sufficient to explain the development of their social knowledge, particularly if one accepts that such mechanisms can lead to rich, sophisticated representations of the elements that make up an animal's environment (Dickinson 1980; Rescorla 1988). Baboons are born into a social world that is filled with statistical regularities: when any two individuals come together, they behave in a predictable way toward each other. All a young baboon has to do is pay attention and remember. As they grow older and observe other animals' behavior, baboons may deduce the existence

of higher order structural regularities that link individuals in complex ways, but the gradual emergence of these more complex mental representations can be fully explained as the result of general learning mechanisms and prodigious memories (see Heyes 1994; Wasserman and Astley 1994; Thompson 1995; Schusterman and Kastak 1998 for examples of this view).

In at least one respect the general process argument must be true. It is hard to imagine how a monkey could learn that two other individuals were members of the same matriline except by grouping them together by virtue of their high rates of association. At the same time, general process hypotheses – developed largely in simplified laboratory conditions – seem unable to explain the complexity of behavior observed in nature, where individuals confront an infinitely more complex set of stimuli.

A young baboon, for example, lives in a world where there are thousands of dyadic (and tens of thousands of triadic) relations that must be memorized and organized into groups. The magnitude of the problem makes one wonder whether simple associative mechanisms are equal to the task. Further complicating matters, no single metric defines a “close” social relationship between two individuals, and some relations are transient whereas others persist for much longer times. Moreover, some relationships are transitive (if A is dominant to B and B is dominant to C, then A is always dominant to C) whereas others are not (if female A1 has a close relation with her sister A2 and with male X1, this does not necessarily mean that A2 and X1 have a close bond). Members of the same matrilineal kin group are in some cases mutually substitutable but in other cases retain their distinct identities (recall the example of kin-biased reconciliation described above). Finally, a baboon can belong to many different classes simultaneously, and membership in a class changes often.

In sum, laboratory experiments designed to explain primate social knowledge in terms of a few general-purpose learning mechanisms typically leave out the very complexity they hope to explain. At present we have no proof that general-process mechanisms are wrong, but there are many reasons to believe that these mechanisms are insufficient to explain baboons’ social knowledge in all of its complexity (for further discussion, see Cheney and Seyfarth 2007).

An alternative, more innatist view begins with the physiological data reviewed earlier. The existence of specialized areas in the brain that are particularly sensitive to conspecific faces, voices, orientation, movement, gaze direction, and intentions, together with areas in the brain that integrate faces and voices into a unified percept, argues strongly that natural selection has favored innate morphological structures that are functionally specialized to recognize conspecifics, attribute motives to them, and take note of their associations.

Further supporting this view, consider the mechanisms that seem to underlie our experimental results. When a female baboon hears another’s female’s vocalization, she does not just hear a sound. She perceives a signal that evokes a representation of the caller, what the caller is doing, her rank and family membership. Baboons seem compelled to respond this way. Just as we cannot hear a word without thinking about its meaning, so a baboon cannot hear a vocalization without thinking about the animal who is calling and the events the call describes. And she cannot hear an

exchange of vocalizations between, say, Sylvia and Hannah without thinking about these animals' identities, ranks, and family membership, about their relationship, and about its place in the social order. When a baboon hears a sequence of calls that violates the existing social order, she responds within seconds and, as far as we can tell, unconsciously. The speed of her response suggests the existence of a social mind that is innately computational and judgmental.

But while the tendency to make social judgments and form a representation of call meaning may be innate, the *content* of these representations changes all the time. Baboons are always monitoring each other and keeping track of who is consorting with whom, who has fallen in rank, who is moving up, and which families are feuding with each other. Within hours of any societal change, they incorporate this new information into their expectations. They have an innately representational mind that is always open to new information.

In sum, we suggest that, just as humans have an innate predisposition to learn language (e.g., Jackendoff 1994; Pinker 1994) and nutcrackers have an innate predisposition to store and remember the location of seeds (Kamil et al. 1994), so baboons have an innate predisposition to recognize other individuals' ranks and social relationships. We are still a long way, though, from knowing how malleable this predisposition is and what mechanisms underlie it. In this respect, we find ourselves in a position much like that of psycholinguists in the late 1950s, when Chomsky wrote his critique of Skinner's *Verbal Behavior*: we know that the system we are studying is complex and that its development cannot be explained by simple learning mechanisms alone, but we do not yet understand how it develops in the minds of our subjects. To quote Chomsky's (1959) review, without the specific references to language and substituting *baboon* for *human*:

"As far as acquisition ... is concerned, it seems clear that reinforcement, casual observation, and natural inquisitiveness (coupled with a strong tendency to imitate) are important factors, as is the remarkable capacity of the baboon to generalize, hypothesize, and 'process information' in a variety of very special and apparently highly complex ways which we cannot yet describe or begin to understand, and which may be largely innate, or may develop through some sort of learning or through maturation of the nervous system. The manner in which such factors operate and interact ... is completely unknown".

7 Do Primates Have Social Theories?

At some point in their lives, all children develop concepts, or theories, about how the world works. Where do these theories come from? Concepts concern features of the world; they provide explanations of why events happen as they do. In this respect, they "embody a systematic set of beliefs that are largely causal in nature" (Keil 1989).

Reviewing studies of children's cognitive development, Keil (1991, 1994) distinguishes between two broadly different hypotheses. "One strongly empiricist account argues that early concepts are devoid of a theory, which then gradually gets overlaid. The other view, which will be called the primal theories account, argues that

concepts are embedded within theorylike relations from the start" (1994, p. 235). According to the latter hypothesis, "even in infancy, some very crude theoretical biases start to be abstracted away" from the regularities observed in the social and physical world (p. 238). In Gopnik and Wellman's (1994) terms, an empiricist child may be able to make generalizations that allow her to predict behavior, but these generalizations do not yet constitute a theory because they "are not far removed from the evidence itself." Theories, in contrast, make "predictions about a wide variety of evidence, including evidence that played no role in the theory's initial construction" (1994, p. 261).

Of course, it would go far beyond the evidence to suggest that baboons have the same kind of explicitly articulated theories or concepts we see in young children. Lacking language, it is difficult to imagine how they could or, even if they did, how they would reveal their knowledge to us.

Thus far, we have proposed that baboons have an innately representational mind whose performance, at least in adults, cannot be explained by simple learning mechanisms. We have also suggested that baboons' physiological and cognitive specializations in the social domain have evolved because they need to solve enormously complicated problems very quickly, and we have argued that simple learning mechanisms are not equal to the task. Finally, we have suggested that baboons' classification of each other, however implicit it may be, is based on the application of certain rules of causality as they are applied to other baboons. Do baboons, then, develop during their lives a *theory* of social life?

There are points at which baboons appear to make deductions that go beyond the mere observations of behavior, deductions that suggest that they have some underlying theory about individual motives and the way they are expressed. Consider the ascription of (what we human observers describe as) matrilineal kinship. Here baboons act as if they have a theory: one that is causal because it is based on assumptions about why individuals behave the way they do ("because they are members of the same matriline"), and one that has generality because it makes predictions about a wide variety of evidence, some of which played no role in the theory's initial construction. On the basis of some minimal observations (as yet unknown), baboons conclude that, if A1 and A2 interact in certain ways in some contexts (when feeding, for example), they must be members of the same matriline and can therefore be counted on to behave in predictable ways in many other contexts, i.e., when forming an alliance or grooming, or reconciling with each other's former opponents. In apparently predicting how kin will interact under a wide variety of circumstances, baboons act as if they have a theory about "matrilineal families:" how they should be recognized and how, once identified, individuals within them should behave. The baboons then use this theory to predict behavior.

We suggest, then, that when it comes to recognizing matrilineal kin groups, baboons are "essentialists" (Gelman et al. 1994). They act as if the members of kin groups "have essences or underlying natures that make them the things that they are." This constitutes a kind of theoretical knowledge because "one of the things that theories do is to embody or provide causal linkages from deeper properties to more superficial or surface properties" (Medin 1989).

Consider, as another example, the baboons' ascription of motives to others. When a baboon hears the sequence "Sylvia threat-grunts and Hannah screams," she responds as if she assumes a causal relation between the two events: the threat-grunt and the scream occurred together not by chance but because the former caused the latter. The listener has no other evidence on which to base this assumption because she cannot see the animals interacting. Only her memory of past interactions can guide her perception of current events. And yet she makes the assumption of causality not just for Sylvia and Hannah but for every combination of females whose calls she hears. The listener acts as if she has a general theory about how individuals – *all* individuals - interact.

In much the same way, recall that, in our experiments, a baboon who grooms with X and then, some minutes later, hears X's threat grunt shows little if any response. She acts as if the threat grunt is not directed at her. In contrast, if the baboon has recently fought with X and then hears X's threat grunt, she responds strongly, as if the threat is meant for her. In these situations, once again, the baboon acts as if she has a theory that is applied to every member of her group, not just X. Individuals with whom you groom are kindly motivated toward you and this motivation is likely to persist over time, whereas individuals who have recently threatened you are not kindly motivated and this, too, predicts their subsequent behavior. Of course, these expectations could arise because individuals have formed relatively simple, Pavlovian associations between, say, grooming with X and subsequent friendly behavior with X. But it is also likely, as it is in young children, that as baboons develop into adults some very crude generalizations, or "theoretical biases" (Keil 1994), have begun to be abstracted away from the regularities observed in the social and physical world.

Finally, it is interesting to note that as children's conceptual skills develop they begin to formulate many different concepts in parallel, concepts that can differ widely in both the objects they include and the causal mechanisms that underlie them (Carey 1985). This finding is useful for the psychologists who study children because, as Keil (1989) points out, "no individual concept can be understood without some understanding of how it relates to other concepts." Here again, baboons provide us with a rich source for speculation because they appear to have different social concepts that follow different rules. Individuals grouped together in the same matriline are assumed, by virtue of this grouping, to behave in certain ways toward each other. Individuals arranged in a linear dominance hierarchy follow different rules. The concepts "matrilineal kin group" and "dominance hierarchy" differ in their essential properties, but they can also be merged to form a more complex concept of "ranked matriline" (Bergman et al. 2003).

8 The Primacy of Social Concepts

Anthropologists and psychologists have often drawn distinctions between two sorts of classification by humans. On the one hand, "biological" classification is typically applied to organisms (plants, animals) other than humans and is based on the

observation that, while variation within a species is continuous, variation between species is discrete, and the assignment of an individual to a particular species has important consequences. The classification of one individual as a raccoon and another as a squirrel implies certain immutable properties or “essences” of each that cannot be changed, even if the individual is dyed a different color, born with a birth defect, or altered in some other superficial way. A gray squirrel painted white is still a gray squirrel. Classification of two individuals as members of different species also implies that some activities (like play) can occur between them but others (successful mating) cannot.

Human classifications of other humans are, by contrast, considerably more complex. Some classifications are termed “natural-like” because they depend on inescapable features of an individual that cannot be altered, chosen, or achieved (Hirschfeld 1994). Examples are classification according to age, gender, race, ethnicity, and membership in a particular lineage. Other classifications are termed “social” because they depend on culturally imposed features that can easily be acquired, lost, or changed. Examples are classification according to profession, elected position, and friendship (Hirschfeld 1994).

Several authors have proposed that both the natural and social categories applied by humans to each other have developed, through knowledge transfer, from the biological categories applied by children to plants and nonhuman creatures. As Atran (1990, p. 74) puts it: “Children might initially borrow from their presumptions of the underlying natures of living things in order to better organize their knowledge of humans...” (see also Boyer 1990; Rothbart and Taylor 1990). From a very early age, children recognize that plants and animals vary in a manner that constitutes discrete kinds (e.g., Gelman et al. 1994); they then apply this “essentialist” thinking to their own species. The transfer of categories thus proceeds from the biological to the social. Totemism, in which human groups are associated with animals and differences between animal species symbolize differences between the groups, is often cited as an example of this transfer (Hirschfeld 1994).

Alternatively, Durkheim and Mauss (1903/1963) believe that classification of any sort by humans is a relatively recent phenomenon, and that when early humans first began to organize things into groups they used their own societies as models for such arrangements (see also Needham 1963). As a result, the transfer of categories occurs in the opposite direction, from humans to animals:

“... the first logical categories were social categories; the first classes of things were classes of men, into which these things were integrated. It was because men were grouped, and thought of themselves in the form of groups, that in their ideas they grouped other things, and in the beginning the two modes of grouping were merged to the point of being indistinct. Moieties were the first genera; clans, the first species.”

This view, that the social and psychological concepts we apply to each other are somehow “primary” and that other classifications derive from them, finds some parallel in Carey’s (1985) proposal that children begin with a naïve, psychological construal of the world and falsely extend their theories (which work well when applied to humans) to other creatures like dogs or worms (where they often fail). Only later do children realize that biological entities like nonhuman species or plants

require a different set of theories from those they apply to humans (see also Keil 1994).

Finally, Hirschfeld (1994) argues against the developmental primacy of either domain. He proposes that there is both a domain-specific competence that underlies humans' essentialist thinking in biology and a domain-specific competence that underlies our essentialist thinking about human social categories. Because the two domains share many similar properties, it is not surprising to find many examples in which thinking in one sphere has been transferred to the other, and vice versa.

At this stage in analysis, our data on baboons have little to say about the extension of knowledge from one domain to another during children's cognitive development. We can, however, adopt a very different perspective and consider the emergence of conceptual thought during human evolution.

Research on baboons raises the possibility that, at some point in history, our ancestors began to recognize and classify members of their own species in ways that were not applied to any other features of their environment. They did so, we suggest, because their socially complex groups created an environment in which an individual's survival and reproduction depended upon her ability to predict other animal's behavior and this, in turn, placed strong selective pressure on individuals to recognize and classify each other (Cheney and Seyfarth 2007). No comparable selective pressure pushed individuals to form comparable classifications of other features of their environment. As a consequence, Durkheim and Mauss were, in evolutionary terms, correct: the first logical categories were social categories, and the first classes of things were classes of conspecifics.

9 Conclusion

Evolution shapes a species' perception and cognition. Among primates, some classes of objects – rocks, clouds – have little effect on the reproductive success of individuals. Subdivisions within these classes are unimportant, so they are perceived and remembered (if they are remembered at all) as generic, undifferentiated groups with no internal structure. Other classes, and the subdivisions within them, have a significant effect on reproductive success. As a result, natural selection has favored individuals whose knowledge of the constituent elements is organized along one or more dimensions. For baboons, the most important features of the environment are other baboons and the crucial dimensions are group membership, dominance rank, matrilineal kinship, and friendships and sexual consortships between males and females.

Compared with those of young children, baboons' theories and concepts are not explicit. Although their social knowledge is implicit, however, this does not make it impoverished.

Baboon social categories constitute representational structures that embody causal explanations of behavior. Baboons recognize other animals' motives and use such attributions to predict their behavior. Their classification of individuals

into matrilineal kin groups both links some individuals with others and attributes to these individuals motives and affinities that predict their behavior across a wide variety of contexts. Baboons are intuitive psychologists.

The baboon mind has evolved not just to deal with specific individuals – although it certainly does this – but also to arrange all individuals into social categories that help to predict their behavior. Baboons have a theory of social life because, in large groups where individuals change often but social categories persist, theories and concepts provide the most efficient solution to the problem of predicting behavior.

We do not yet know whether baboon social knowledge is largely innate or develops from experience. Nor can we tell, yet, whether the kind of social categories found in baboons are unique to primates or occur in many other group-living birds and mammals. We can propose, however, that baboon social knowledge sheds light on the evolution of domain-specific social intelligence in humans. Long before they classified other features of the world and developed conceptual knowledge about features outside the social domain, our ancestors classified and reasoned about each other.

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Uncorrected Proof