Primate social cognition and the origins of language

Robert M. Seyfarth, Dorothy L. Cheney and Thore J. Bergman

Departments of Biology and Psychology, University of Pennsylvania, Philadelphia, PA 19104, USA

Are the cognitive mechanisms underlying language unique, or can similar mechanisms be found in other domains? Recent field experiments demonstrate that baboons' knowledge of their companions' social relationships is based on discrete-valued traits (identity, rank, kinship) that are combined to create a representation of social relations that is hierarchically structured, open-ended, rule-governed, and independent of sensory modality. The mechanisms underlying language might have evolved from the social knowledge of our pre-linguistic primate ancestors.

It is widely believed that the mechanisms underlying modern language did not appear *de novo* but instead evolved from pre-existing cognitive skills. For example, both Newmeyer [1] and Pinker and Bloom [2] propose that, during its evolution, grammar 'exploited mechanisms originally used for conceptualization.' As a general working hypothesis this seems reasonable, but can we be more specific? What kind of conceptual structure? Concepts about what? Recent field experiments on the social knowledge of baboons (*Papio cynocephalus ursinus*) reveal a hierarchical, rule-governed structure with many properties similar to those found in human language.

The social background

Baboons are Old World monkeys that shared a common ancestor with humans approximately 36 million years ago [3]. They live throughout the savannah woodlands of Africa in groups of 50–150 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. Females can be ranked in a stable, linear dominance hierarchy that determines priority of access to resources. Offspring acquire ranks similar to those of their mothers. Baboon social structure can therefore be described as a hierarchy of matrilines, in which all members of one matriline (e.g. matriline B) outrank or are outranked by all members of another (e.g. matrilines C and A, respectively). Ranks within matrilines are as stable as those between matrilines (e.g. $A_1 > A_2 > B_1 > B_2 > B_3$) [4]. The research described here was conducted on a group of about 80 individuals, including 20–25 adult females, living in the Okavango Delta of Botswana. The group has been observed for 25 years.

Corresponding author: Seyfarth, R.M. (seyfarth@psych.upenn.edu).
Available online 27 April 2005

Social knowledge

Given the complexity of their society, it seems reasonable to ask whether baboons themselves recognize the rank and kin relations that are so apparent to a human observer. Early experiments showed that baboons do, indeed, recognize other individuals' dominance ranks as well as the close bonds that exist among matrilineal kin (see Box 1). More recently, we asked whether baboons classify others simultaneously according to rank and kinship, and thus recognize that their group is composed of a hierarchy of families. Adult female baboons heard sequences of threat-grunts and screams that mimicked a fight between two unrelated females. One sequence consisted of an anomalous threat-grunt-scream sequence mimicking a *within-family* rank reversal (e.g. B_3 threat-grunts and B_1 screams; see Figure 1). A second consisted of an anomalous sequence mimicking a *between-family* rank reversal (e.g. C_3 threat-grunts and B_1 screams). The third consisted of a no-reversal control sequence consistent with the female dominance hierarchy (e.g. B_1 threat-grunts and B_3 screams, or B_3 threat-grunts and C_1 screams).

If baboons classify others simultaneously according to both individual attributes (rank) and membership in a higher-order class (matriline), they should have responded more strongly to the apparent between-family rank reversal than to the within-family rank reversal. A between-family rank reversal is potentially much more significant than a within-family rank reversal because it signals a possible change in the dominance relations of two entire matrilines rather than just two individuals

Box 1. Using vocal playback experiments to study social knowledge

Baboon vocalizations exhibit two properties that make them ideal for experimental studies of social cognition: calls are individually distinctive [15,16] and different call types are given in highly predictable circumstances. Distinctive 'threat-grunts', for example, are given only by higher-ranking individuals to those of lower rank, whereas screams and 'fear barks' are given only by subordinate individuals as signals of submission. An early playback experiment tested baboons' knowledge of other individuals' ranks using a 'violation of expectation' paradigm [17]. Subjects heard either a naturally-occurring sequence of calls consistent with the existing dominance hierarchy (e.g. B_2 grunts and C_3 fear-barks) or an experimental sequence that violated the hierarchy (C_3 grunts and B_2 fear-barks). Regardless of their own relative ranks, subjects looked toward the speaker for significantly longer durations to call sequences that violated the existing hierarchy than to those that did not [17]. They appeared to recognize other animals' rank relations. Other experiments demonstrated that individuals recognize the close bonds that exist among matrilineal kin [18].

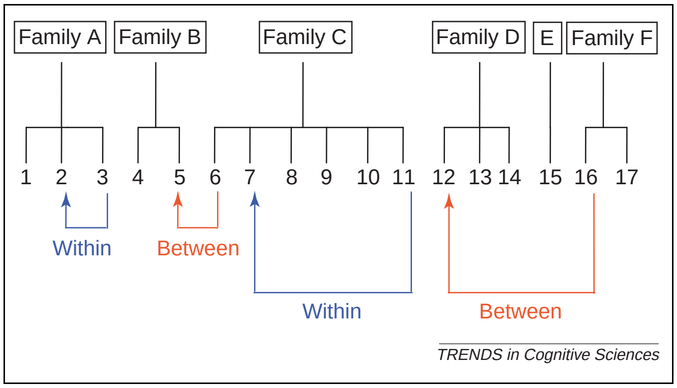


Figure 1. Hierarchical organization of a baboon group and the design of playback experiments. Matrilineal families (A–F) are listed left to right in descending rank order. In the study by Bergman *et al.* [5], a within-family rank reversal was simulated by combining a threat-grunt from a lower-ranking member of one family (for example individual A_3) with a scream from a higher-ranking member of the same family (A_2). A between-family rank reversal was simulated by combining a threat-grunt from a lower-ranking member of one family (C_6) with a scream from a higher-ranking individual in a higher-ranking family (B_5). By selecting calls from subjects in large and small families, it was possible to control for rank distance between subjects.

within the same family. This was indeed the case [5] (see Figure 2). By contrast, subjects responded relatively weakly both to sequences that mimicked a within-family rank reversal and to those in which no reversal took place.

Social cognition and language

Baboons' social knowledge shares several properties with human language that might be relevant to theories of language evolution. First, knowledge is **representational**. When a baboon hears a vocalization, she acquires specific information about a particular sort of interaction between specific individuals.

Second, knowledge is based on properties that have **discrete values**, such as individual identity, sex, matrilineal kin group, and dominance rank [6].

Third, animals combine these discrete-valued traits to create a representation of social relations that is **hierarchically structured**. Baboons appear simultaneously to rank individuals in a linear order and group them according to matrilineal kinship in a manner that preserves ranks both within and across families.

Fourth, knowledge is **rule-governed** and **open-ended**. Baboons recognize that vocalizations follow certain rules of directionality (for example, screams are only given by subordinates to dominants), and that directionality should conform to the existing dominance hierarchy. The hierarchy is open-ended because new individuals can be added or eliminated without altering the underlying structure, and because the set of all possible interactions is very large [6,7].

Fifth, knowledge is **independent of sensory modality**. Although playback experiments demonstrate that information about social interactions can be acquired through vocalizations alone, social knowledge is also obtained visually, by observing interactions among others [8].

Finally, the information thus obtained is, loosely speaking, **propositional**. In tests mimicking within- and between-family rank reversals, subjects heard a series of threat-grunts and screams. Their responses

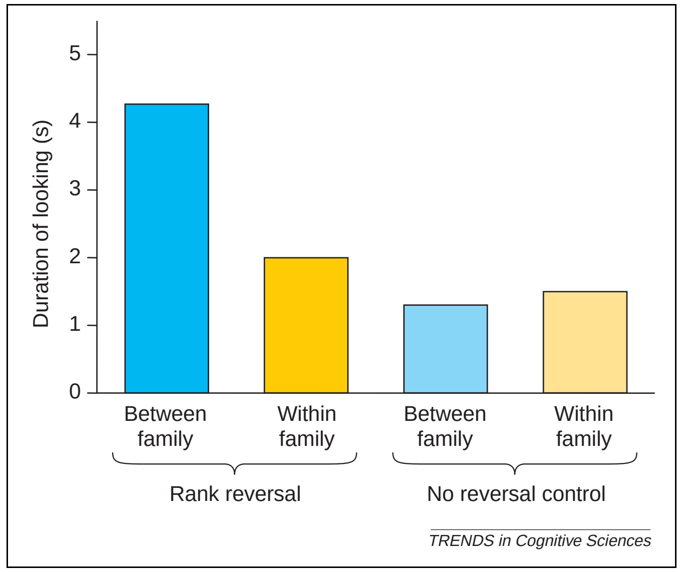


Figure 2. Subjects' responses to playback of between-family rank reversals (N=19), within-family rank reversals (N=18), and to call sequences that signaled no reversal of rank (N=18). In a within-subject analysis, between-family rank reversals elicited a significantly stronger response (longer looking durations towards the speaker) when compared with other conditions [5].

suggested that they parsed these calls as a narrative involving an agent, an action, and a recipient, for example: '*Sylvia is threatening Hannah and this is causing Hannah to scream*'.

Note that agents, actions and recipients are not coded in the way we usually encounter them in language. For baboons hearing the call sequence described above, agent and action are coded in the threat-grunts, which are recognizable as aggressive vocalizations and identifiable as Sylvia's. The same holds for Hannah's screams. Although the precise order of calls seems relatively unimportant in listeners' assessment of the event, their temporal and spatial juxtaposition is not. Listeners behave as if they assume that the calls do not occur together by chance, but instead are juxtaposed because Sylvia's threat-grunt *caused* Hannah's scream. We hypothesize, therefore, that the propositional information baboons acquire when they hear vocalizations includes an understanding of the causal relations that link an actor's threat-grunts and a recipient's screams.

Combining vocalizations

Of course, this call sequence differs strikingly from a sentence because it was produced by two individuals, each of whom was using a single call type that is predictably linked to a narrowly defined social situation. Taken alone, neither animal's calls could even remotely be described as linguistic. Together, however, the two animals produce a sequence that is interpreted by listeners in a manner that resembles the way we interpret sentences, both in the information acquired and in the manner of its construction. Baboons acquire propositional information by combining their knowledge of call types, callers, and the callers' places in a social network, and by assuming a causal relation between one animal's vocalizations and another's.

The sound sequence created by the combination of Sylvia's threat-grunts and Hannah's screams is also striking because, from the listener's perspective, it represents a concatenation of two vocalizations, each meaningful on its own, into a larger meaningful utterance. In principle, a very large number of such combinations is possible, limited only by the size of the group. Among non-human species, such call combinations are rarely produced by a single individual; however, listeners in group-living primates confront them whenever they hear two animals vocalizing to one another.

A 'social origins' hypothesis for language

The results described here are consistent with a 'social origins' hypothesis, which argues that the internal representations of language meaning evolved partly from our pre-linguistic ancestors' knowledge of social relations [6–10]. Like modern monkeys and apes, our ancestors lived in groups with intricate networks of relationships that were simultaneously competitive and cooperative. The demands of social life created selective pressures for just the kind of complex, abstract, conceptual, and computational abilities that are likely to have preceded the earliest forms of linguistic communication.

Although baboons have concepts and acquire propositional information from other animals' vocalizations, they cannot articulate this information [11]. They understand dominance relations and matrilineal kinship but have no words for them. This suggests that the internal representation of many concepts, relations, and action sequences does not require language, and that language did not evolve because it was uniquely suited to representing thought [11–14].

Before the emergence of language, hominids assigned meaning to other individuals' calls and extracted rule-governed, propositional information from them. A crucial step in language evolution occurred when individuals came under strong selection pressure to communicate their thoughts, as opposed to simply extracting information from the calls of others.

References

1 Newmeyer, F. (2003) Grammar is grammar and usage is usage. *Language* 79, 682–707
2 Pinker, S. and Bloom, P. (1990) Natural language and natural selection. *Behav. Brain Sci.* 13, 713–783
3 Boyd, R. and Silk, J.B. (2000) *How Humans Evolved* (2nd edn), W.W. Norton
4 Silk, J.B. *et al.* (1999) The structure of social relationships among female savanna baboons. *Behaviour* 136, 679–703
5 Bergman, T.J. *et al.* (2003) Hierarchical classification by rank and kinship in baboons. *Science* 302, 1234–1236
6 Worden, R. (1998) The evolution of language from social intelligence. In *Approaches to the Evolution of Language* (Hurford, J.R. *et al.*, eds), pp. 148–168, Cambridge University Press
7 Seyfarth, R.M. and Cheney, D.L. (2003) The structure of social knowledge in monkeys. In *Animal Social Complexity: Intelligence, Culture, and Individualized Societies* (de Waal, F. and Tyack, P., eds), pp. 207–229, Harvard University Press
8 Kummer, H. (1978) On the value of social relationships to nonhuman primates: A heuristic scheme. *Soc. Sci. Inf. (Paris)* 17, 687–705
9 Cheney, D.L. and Seyfarth, R.M. (1997) Why animals don't have language. *The Tanner Lectures on Human Values* 19, 173–210
10 Dunbar, R.I.M. (1998) Theory of mind and the evolution of language. In *Approaches to the Evolution of Language* (Hurford, J.R. *et al.*, eds), pp. 92–110, Cambridge University Press
11 Cheney, D.L. and Seyfarth, R.M. (2005) Constraints and preadaptations in the earliest stages of language evolution. *Linguistic Review*
12 Hurford, J. (2002) The role of expression and representation in language evolution. In *The Transition to Language* (Wray, A., ed.), pp. 311–334, Oxford University Press
13 Hespos, S.J. and Spelke, E. (2004) Conceptual precursors to language. *Nature* 430, 453–456
14 Hauser, M.D. *et al.* (2002) The faculty of language: What is it, who has it, and how did it evolve? *Science* 298, 1569–1579
15 Owren, M.J. *et al.* (1997) The acoustic features of vowel-like grunt calls in chacma baboons: Implications for production processes and function. *J. Acoust. Soc. Am.* 101, 2951–2963
16 Snowdon, C.T. (1990) Language capacities of nonhuman primates. *Yearb. Phys. Anthropol.* 33, 215–243
17 Cheney, D.L. *et al.* (1995) The responses of female baboons to anomalous social interactions: Evidence for causal reasoning? *J. Comp. Psychol.* 109, 134–141
18 Cheney, D.L. and Seyfarth, R.M. (1999) Recognition of other individuals' social relationships by female baboons. *Anim. Behav.* 58, 67–75

doi:10.1016/j.tics.2005.04.001

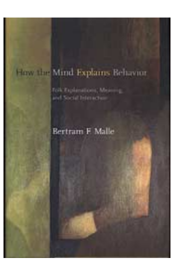
Book Reviews

Explaining explanations of behavior

How the Mind Explains Behavior by Bertram F. Malle. MIT Press, 2004. $38.00/£24.95 (314 pp.) ISBN 0 262 13445 4

India Morrison

Centre for Cognitive Neuroscience, University of Wales Bangor, Bangor, Gwynedd LL57 2AS, UK



When did the universe begin? How does a bird fly? These are perennial questions that have echoed through human history. But – let's face it – the eternal questions that figure much larger in our daily lives are more along the lines of: 'Why oh *why* did he do that?' and 'What could she possibly have been *thinking*?'

Corresponding author: Morrison, I. (pspc46@bangor.ac.uk).
Available online 27 April 2005

In a world full of other people, explaining human behavior is crucial. For those in the business of explaining behavior scientifically, it is just as crucial to examine the interpretive structures upon which behavior explanations are built. Bertram Malle's *How the Mind Explains Behavior* offers a model for the conceptual framework we use to sift and classify mental-state representations in order to select explanations about behavior. Although written mainly in the context of issues in the social psychology tradition, it would make enriching reading for