

Primate Cognition: Introduction to the Issue

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I introduce the special issue by: (1) outlining something of the relationship between mainstream cognitive science and the study of nonhuman primate cognition; (2) providing a brief overview of the scientific study of primate cognition and how the papers of this special issue fit into that scientific paradigm; and (3) explicating my own views about the relationship between nonhuman primate cognition and human cognition.

I. INTRODUCTION

To introduce this special issue, I do three things. First, I sketch out very briefly the somewhat problematic relationship between mainstream cognitive science and the study of nonhuman primate cognition. Second, I provide a very broad overview of the role of cognitive processes in the lives primates, attempting in the process to situate the various topics of the individual papers of this volume. And third, I explicate one hypothesis for how processes of nonhuman primate cognition relate to processes of human cognition.

II. COGNITIVE SCIENCE AND PRIMATE COGNITION

Cognitive science is mainly about human cognition, and it should be. But human cognition is a specific (in the literal meaning of the word) instance of primate cognition, and evolution by means of natural selection is a mostly conservative process that preserves adaptations that work for as long as they work. Human cognition is thus not just similar to nonhuman primate cognition, it is identical in many of its structures. The study of nonhuman primate cognition should therefore play a more important role in cognitive science than is currently the case. Reasons for the lack of communication between the two disciplines emanate from both directions.

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From the point of view of primatology, the problem is that historically most students of primate behavior are either behavioral biologists (ethologists) or physical anthropologists. The major concerns of these scientists are issues of survival, adaptation, and reproductive success. These are interesting and important issues in their own right, of course, but they are directly relevant to the study of cognitive science only when they involve cognitive adaptations, that is, adaptive mechanisms that work by empowering individual organisms to make behavioral decisions based on mentally represented information. Cognitive mechanisms of this type are typically not studied by behavioral biologists and physical anthropologists, and indeed in many circles they are viewed with suspicion as anthropomorphic impositions.

In the past two decades this situation has begun to change as more and more psychologists interested in cognitive mechanisms have begun to study nonhuman primates. There were of course some psychological investigations of primate cognition in the early part of the century by such pioneers as Yerkes and Kohler, and, after some behavioristic forays into processes of discrimination learning by Harlowe and colleagues, also in the 1960s and 1970s by modern pioneers such as Premack and Menzel. But the field of Cognitive Ethology did not come into its own until the 1980s with studies such as those of Seyfarth, Cheney, and Marler (1980) on reference and mental representation in the communication of vervet monkeys and of de Waal (1982) on the “political” maneuverings of chimpanzees in their natural social interactions.

Even in cognitive ethology, however, cognitive science has not played a major role. The problem is that most cognitive ethologists take an explicitly ecological point of view. It does not seem plausible to most cognitive ethologists that mentally representing experience is a generalized biological function with its own separate and coherent adaptive story. Instead, it seems more likely that mental representation becomes an important part of some specific behavioral adaptations for some species - for example, as they deal with navigation in space, quantifying food, or communicating with conspecifics. The kinds of generalized models of knowledge representation common in mainstream cognitive science have therefore not seemed particularly useful to cognitive ethologists. This lack of fit is only exacerbated by the fact that most human-based models are symbolic in nature, and nonhuman primates do not use language or engage in other forms of symbolic activity in their natural environments. There are some signs that this is beginning to change, however, as theorists such as Cheney and Seyfarth (1990) and Byrne (1995) have drawn explicitly on models from cognitive science, and more and more researchers are attending to research concerning the cognitive development of human children (although developmental research is typically not thought of as mainstream cognitive science).

For its part, cognitive science has also contributed to the lack of communication between the two fields, as it has had little use for the bits and scraps of information on animal cognition heretofore available. In addition—and perhaps most importantly—throughout its recent history mainstream cognitive science has been most vigorously concerned with issues of knowledge, information, symbols, language, and mental representation as separate from more ecologically based skills grounded in perception, action,

emotion, and social life—a set of concerns that emanate at least partly from the epistemological and implementational challenges posed by various forms of artificial intelligence. The point is that with these set of concerns in mind, studies of nonlinguistic organisms, who apparently do not engage in any interesting forms of symbolic activity or linguistic communication, do not seem particularly relevant or useful.

But there are signs that cognitive science is broadening its horizons in directions that should facilitate communication with students of primate cognition as well. More ecological approaches to human cognitive functioning have begun to find a wider audience (e.g., Neisser, 1984; Norman, 1993; Hutchins, 1995); there is more concern with emotional and social life as essential aspects of human cognition (Bruner, 1990; Damasio, 1994); there is more concern with issues of perceptual and bodily engagement with the environment (Johnson, 1987; Lakoff, 1987); and, most directly, more and more cognitive scientists are becoming interested in evolutionary issues and approaches to human cognition (e.g., see several entries on animal cognition in the forthcoming *MIT Encyclopedia of the Cognitive Sciences*). In addition, the new approaches to the formalization of cognition that take a nonsymbolic stance—for example, the various forms of connectionist modeling (Ellman et al., 1996) and perhaps some forms of perceptually based modeling (Barsalou, in press; Langacker, 1987)—would seem to open up new possibilities for theoretical continuity with those studying nonsymbolic organisms.

Most cognitive scientists are familiar with at least some of the classic studies of primate cognition, but they are less familiar with the more recent studies that are being published at an ever increasing rate. The aim of the current special issue is to try to bring cognitive scientists up to date on this rapidly growing and expanding field of study, and thereby, hopefully, to increase communication between the fields. Recent research has determined that primates use a variety of cognitive strategies—variously defined but all relying on the organism's active use of some form of mental representation—in understanding such things as space, tools, object categories, quantities, causality, and the behavior and perhaps mental lives of conspecifics in interactions involving cooperation, competition, communication, and social learning. The papers in this special issue represent overviews of some of the major areas of study in primate cognition by some of the most accomplished researchers from the general perspective of cognitive ethology. This new work should provide important information and perspectives for those interested in exploring the evolutionary roots of the cognitive processes by means of which human beings make sense of their worlds.

III. COGNITION IN THE LIVES OF PRIMATES

Primates emerged as a separate order of mammal some 60 million years ago (their closest living relatives being the Insectivores, e.g., moles, shrews, and hedgehogs). Their most distinctive morphological adaptation is their hands, which have evolved for arboreal life in general and especially for the obtaining and processing of food items (Passingham, 1982). But primates have also evolved a number of behavioral adaptations, some of which may qualify as cognitive. Cognitive adaptations are behavioral adaptations in which the

individual organism must make flexible behavioral choices based on individually acquired, mentally represented information (Menzel & Wyers, 1981). Primates have a relatively long period of immaturity (even longer than other mammals; Richard, 1985) in which they may learn whatever is needed to make flexible and informed decisions of this type.

Primates may be in special need of flexible cognitive adaptations because they face problems of special complexity as they engage in the two essential activities of all mammals: foraging for food and interacting with conspecifics socially (including mating). In terms of foraging, Milton (1981) argued that foraging presents special challenges for primates relative to other mammals. She argued that primates evolved as arboreal animals who foraged for foods that were patchily distributed in time and space, especially fruits that occur only intermittently throughout tropical rainforests and are only ripe at some seasons of the year. Milton proposed that this ecological fact might be responsible for primates' large brains and great intelligence: they have to remember much about foods and their spatio-temporal distributions. Parker and Gibson (1979) proposed that the key was "extractive foraging" in which individuals need to mentally represent food items hidden inside shells, tree trunks, or piles of leaves, as they searched for them (although many nonprimates engage in this kind of foraging just as frequently as primates; King, 1986).

Tomasello and Call (1997) attempted to decompose primate foraging into the different cognitive problems involved, that might be at least partially dissociable from one another. In order to obtain their daily sustenance, primates need to: (1) find food, (2) obtain/process food, and (3) identify/categorize/quantify food. In the current volume, Call focuses on the first two of these as primates form cognitive maps of their spatial layouts in order to find food, and they use insightful cognitive strategies to manipulate and extract food from difficult substrates so that it can be eaten. Thompson focuses on how primates categorize their worlds, with attention not only to object categories, but also to relational categories - which are perhaps of special importance in distinguishing primate cognition from that of other mammals (Tomasello, 1998). Boysen is concerned with primate skills of quantification, and in particular with their ability to understand something akin to human number.

In terms of social interaction, in recent years there has arisen a group of theorists who argue that primate cognition arose in response not to foraging or other tasks performed in the physical world, but rather in response to the demands of a complex social life. DeWaal (1982) has captured this idea succinctly in the expression primate politics, as have Byrne and Whiten (1988) in their related expression Machiavellian Intelligence. The basic idea is that other animate beings do not just sit around like food waiting to be found and manipulated, but they have social strategies of their own. What develops is a kind of cognitive "arms race" in which every adaptation by one individual is responded to by conspecifics with their own adaptation, which requires a counter-response, and so on in the "blood and claw" of survival of the fittest. In opposition to this nakedly competitive view—but not exclusive of it—is the more benign view that primate individuals may gain adaptive advantage by cooperating with selected friends and learning important things

from one another socially (King, 1994). Cheney et al. (1987) have reviewed the evidence and argued that primate social interactions are especially complex compared to those of other mammals (all of whom recognize individual groupmates and form social relationships with them), especially in terms of the number and nature of social relationships formed and the range of communicative mechanisms utilized.

From the point of view of the cognitive mechanisms required to deal with social complexity, Tomasello and Call (1997) again attempted to break the problem down into its component parts by noting that conspecifics differ from inanimate objects in three main ways. That is, in addition to being physical objects to be located, identified, quantified, and physically pushed and pulled, animate beings also: (1) behave autonomously and so afford various types of social interaction involving cooperation and competition; (2) are best manipulated not by physical pushing and pulling, but by communicative signals; and (3) may be used as sources of information in various types of social learning. These three characteristics make conspecifics more complex cognitive entities than food or other inanimate objects, and thus lead to specific kinds of cognitive adaptations. In the current volume, Hauser relates some of the complexities involved as primates communicate, and sometimes deceive, one another in various types of social interaction. Whiten deals with processes of primate social learning, which are interesting in their own right as social-cognitive processes but which also raise issues of cultural transmission as well—and cultural transmission is of special importance because it raises the possibility of acquiring cognitive skills and information vicariously. Povinelli concentrates on recent research on how primates understand the behavior, perception, and perhaps mental lives of other animate beings, that is, their “theories of mind.”

These two sets of adaptive problems—*foraging* and *social interaction*—may thus present special difficulties for primates relative to other mammals. The result is an order of mammal with a relatively large brain relative to body size (with an expanded neocortex; Jerison, 1973; Dunbar, 1992) that learns much of what it needs to know during ontogeny and deploys that knowledge flexibly in all kinds of complex foraging and social situations. Whether foraging or social interaction was the major force in primate cognitive evolution is currently an unresolved question, but general support for the social view has recently been provided by Dunbar (1995) who found that primate brain size does not correlate highly with size of foraging range (an operationalization of spatio-temporal complexity), but it does correlate highly with size of social group (an operationalization of social complexity). Byrne’s theoretical chapter focuses on precisely this issue, and he seeks to provide some assessment of the role of these two different sets of adaptive problems in the evolution of primate cognition.

It should be noted that there is one important omission in the current set of papers. There are no surveys of what is known about the cognitive skills of individual nonhuman primates, mostly apes, who have been raised by human beings in human-like cultural environments containing all kinds of cultural artifacts including language-like communicative symbols—what have sometimes been called “enculturated” apes. Although anecdotes surface with regularity from various places, the truth is that there is very little rigorous scientific work with these individuals going on at this time. The major exception

is the work of the Rumbaugh's at the Language Research Center of Georgia State University. Their most thorough work on the language comprehension skills of one particular individual, a bonobo named Kanzi, may be found in Savage-Rumbaugh, Murphy, Sevcik, Braake, Williams, and Rumbaugh (1993; see also Tomasello, 1994). In a recent survey of work with these individuals, Call and Tomasello (1996) concluded that whereas ontogeny in a human-like cultural environment does not affect basic skills of physical cognition (space, object permanence, and so forth), it does seem to affect basic skills of social cognition (communication, social learning, etc.).

IV. TWO HYPOTHESES

Tomasello and Call (1997) reviewed all of the most significant literature on primate cognition. On the basis of this review they offered two hypotheses: one concerning what makes primate cognition unique as compared with that of other mammals, and one concerning what makes human cognition unique as compared with that of other primates. Because most of the current volume deals with primates exclusively, I offer these hypotheses in the spirit of stimulating thought and discussion about how primate cognition compares and contrasts with that of other animal species including humans.

On the basis of their review, Tomasello and Call (1997) argued and presented evidence that only primates form relational categories, that is, categories of relations that may be discerned between two or more entities external to the observing organism. One line of evidence for this conclusion comes from discrimination learning experiments involving transitivity, relation matching, and the like (see Thompson, this volume). These tasks are easily solved by many primate species in ways that indicate a deep understanding of the problem (not just the learning of discriminative cues), whereas they are not dealt with in this same way by other animal species. The second line of evidence comes from studies of social interaction in which primates seem to understand not just their own relationships with groupmates, but also the relationships those groupmates have with one another—including both the vertical dimension of social structure (dominance) and the horizontal dimension of social structure (kinship-friendship). For example, it is a common occurrence that when one individual attacks another, that second individual responds by attacking the kin of the first individual, thus showing its understanding of their kinship relation. There are six other naturally occurring phenomena that suggest this same social understanding and two experimental studies that corroborate the interpretation in terms of an understanding of relational categories. There is basically no such evidence, either naturalistic or experimental, from nonprimate animal species.

Following Humphrey (1976), Tomasello and Call (1997) argued further that primates' ability to form relational categories very likely evolved to deal with social relationships. Although there is very little relevant evidence one way or the other, the speculation is that forming relational categories of physical objects would not be of great adaptive significance to primates in any of their most important activities, including foraging. On the other hand, the ability to assess the social relationship that two groupmates have with one another comes into play in all types of social interactions. For example, such a cognitive

skill would be of great benefit to individuals seeking allies in a fight, or assessing their chances of mating with other individuals, or, in general, behaving effectively socially.

Tomasello and Call (1997) also attempted to situate human cognition in the context of this hypothesis about uniquely primate cognition. Briefly, they argued that human beings continued along this line in the understanding of the relations among outside entities, but in the case of humans the relations they came to understand involved intentionality in the social domain and causality in the physical domain. Understanding intentionality and causality involves understanding the dynamic relation of an antecedent event to a consequent event in terms of some mediating force that somehow explains “why” the first invariably leads to the second. In the physical realm this leads to a much more flexible approach to problem solving as individuals may substitute antecedent events so long as they initiate the same mediating force (e.g., finding a novel way to crack open a nut), and they may prevent consequent events by blocking the antecedent’s initiation of the mediating force.

In the social realm, understanding mediating forces means understanding that others are intentional beings whose behavior is guided by mediating forces such as goals and perceptions, which also leads to much more flexible problem solving in the social domain. But the understanding of intentionality has another, even more important consequent, and that is the types of cultural learning and cultural cognition it generates. Cultural processes not only allow the organism to benefit from the skills and knowledge of conspecifics, they also lead to some unique forms of cognitive representation involving intersubjectively shared symbols.

Following the lead of Vygotsky (1978), Bruner (1990), Cole (1996), and other cultural psychologists, my view is that what makes human cognition unique, more than anything else, is its collective nature (Tomasello, 1999). That is, all of the many artifacts that enable and empower human cognition—from spoons, hoes, buildings, and computers, to languages, numerals, maps, and professional meetings—are the joint product of many people working over many years, combining and accumulating skills and knowledge. The key needed for entry into this collectivity is what Tomasello, Kruger, and Ratner (1993) called cultural learning. In cultural learning young children learn to use the tools, artifacts, symbols, and other cognitive amplifiers of their culture by attempting to reproduce adults’ intentional relations to them, or more precisely, adults’ intentional relations to the world as mediated through these artifacts. Cultural learning thus depends crucially on the ability of individuals to understand the behavior of others as intentional, and human children begin down this path at the end of their first year of life as they start to engage in all kinds of joint attentional interactions with others including gaze following, social referencing, imitation of actions on objects, and gestural communication (Tomasello, 1995).

Because other primates do not understand conspecifics intentionally, they do not engage in cultural learning of this type, and, as a consequence, their societies do not follow the trajectory of human cultures in which the cognitive achievements of individuals accumulate and become embodied in artifacts over time - so that developing children are able to participate in the whole cognitive history of their species. Although there is certainly some controversy over these issues, by all indications nonhuman primates do not

understand others as intentional beings. They clearly understand others as animate beings that self-generate behavior and behave in certain predictable ways. But they do not seem to understand their conspecifics as intentional agents like themselves who experience the world in ways similar to themselves. As evidence for this fact it may be noted that in their communication with conspecifics, nonhuman primates do not point to distal entities in their environments, they do not hold up objects for others to see and share, and they do not actively give or offer objects to other individuals. They also do not actively teach one another, and the kinds of cooperation in which they engage are very simple and basic (i.e., they cooperate without an understanding of the role of the other; Kruger and Tomasello, 1996). In all, nonhuman primates simply do not seem to have an understanding of others as intentional agents whose mental lives they may affect through their own communicative, pedagogical, or cooperative efforts (see Tomasello, 1996, and Tomasello & Call, 1997, for critical reviews of some experimental findings on apes' "theory of mind").

One further consequence of the human adaptation for cultural life is the changes that the acquisition of language brings about in cognitive representation. There are three important features of cognitive representation by means of linguistic symbols: their intersubjective nature, their perspectival nature, and their representation of complex events. First, linguistic symbols are intersubjectively shared in the sense that the user of a symbol simultaneously comprehends the symbol and knows that the listener also comprehends it (Tomasello, 2000). Linguistic symbols thus transform the nature of human cognitive representation by supplying users with socially shared and readily manipulable signifiers (the actual physical symbols) for many of their most important experiences (Bates, 1979).

Second, linguistic symbols do not just represent individual episodic experiences, but rather they stand for whole categories of experience—entities that may be considered similar for some particular purpose. Linguistic symbols are used by persons to direct the attention of other persons to one particular way of conceptualizing a particular phenomenon as opposed to other possible ways, for example, calling a particular piece of real estate either *the coast*, *the shore*, or *the beach*, depending on the communicative context (see Langacker, 1987, on construal operations). As they acquire the conventional use of linguistic symbols young children must come to understand that a particular scene can be viewed either as *John broke the window* or *The window broke*, that we can either see a scene as *The cat is fleeing the dog* or *The dog is chasing the cat*. Linguistic symbols are thus not only intersubjective, they are perspectival (Clark, 1997; Tomasello, 1999). Children's mastery of the conventional use of linguistic symbols thus implies an understanding of the myriad different perspectives that may be taken on the same phenomenon, and thus represents an evolutionarily new form of cognitive representation.

In addition to the fact that linguistic symbols are intersubjective and perspectival, they also involve the symbolization of events—complex situations involving one or more participants in an event or state of affairs (Mandler, 1992; Nelson, 1996). Interestingly, the prototypical events that young children understand and express in their earliest language all involve the intentional action of a human agent (Slobin, 1985). Thus, across all of the world's languages young children find it interesting and important to talk about such

things as the human manipulation of objects, the human exchange and possession of objects, the movements and changes of state of people and objects, and basic processes of social interaction. Indeed, the conceptualization and categorization of events is the fundamental organizational principle of early language development (Tomasello, 1992). The result is that from their second year of life human children symbolically represent their shared experiences with others in terms of particular perspectives on temporally extended events and their multiple participants - all in identifiable conceptual packages. The cognition of the 2- to 3-year-old human child is thus very different from that of any other primate, most especially because it includes an understanding of intentional action and is therefore organized in terms of symbols, perspectives, and event categories.

The argument is thus that human beings share with nonhuman primates all of their cognitive adaptations for space, objects, tools, categorization, quantification, understanding social relationships, communication, social learning, and social cognition. But building on these adaptations, they also have a unique adaptation, or set of adaptations, for social-cultural life by means of which they “tune in” to other persons in their group, for example, by imitating them, learning to use their material tools, learning to use their symbols to communicate with them, teaching and being taught by them, and collaborating with them in complex ways. The outcome of this type of social life is not just that individuals benefit from the information gathered by others, but they also begin to employ novel forms of cognitive representation and organization, for example, forms of cognitive representation based on intersubjectively understood symbols and the taking of multiple perspectives on cognized entities and events (Donald, 1991; Tomasello et al., 1993). The hypothesis is thus that if a human child were raised from birth outside of human contact and culture, without exposure to human artifacts or communal activities of any kind, that child would develop few of the cognitive skills that make human cognition so distinctive (see Candland, 1993, for an interesting discussion, although the scientific data on “wild children” is problematic in many respects).

There are of course no shortage of speculations about human cognitive uniqueness, and so my own line of speculation should be taken with the usual grain of salt. But it is important in the current context to spell out at least one such scenario because the role of social and cultural factors in the phylogeny and ontogeny of human cognition is not a topic that has received sufficient attention in mainstream cognitive science. In contrast, much of the most exciting research and theory into primate cognition is currently focused directly on processes of social cognition, and how these may underlie the unique cognitive adaptations of primates as an order, as well as those of *Homo sapiens* as a species.

V. THE VOLUME

The authors of the papers that follow were charged with providing the readers of *Cognitive Science* with some basic facts and theoretical perspectives on nonhuman primate cognition. They represent a number of different content areas and theoretical points of view—not all of which are consistent with the views I have expressed in this somewhat personal introduction. One thing is for certain: a reader who reads and thinks carefully

about the content of all of these papers will have a very good knowledge and understanding of the field of primate cognition as it now stands. Hopefully, then, this special issue of *Cognitive Science* will serve as a vehicle by means of which cognitive scientists will become more interested in the evolutionary aspects of human cognition, leading to more substantive interactions among scientists in the two fields.

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