

Why Animals Don't Have Language

*DOROTHY L. CHENEY AND
ROBERT M. SEYFARTH*

THE TANNER LECTURES ON HUMAN VALUES

Delivered at

Cambridge University

March 10–12, 1997

DOROTHY L. CHENEY is a professor of biology at the University of Pennsylvania, where she has also taught in the department of anthropology. She received her B.A. from Wellesley College, studied at the London School of Economics, and received her Ph.D. from Cambridge. She is a member of the Animal Behavior Society, the Behavioral Ecology Society, the American Society of Primatologists, and the International Society of Primatologists. She was a fellow at the Center for Advanced Study in the Behavioral Sciences at Stanford and recipient of a Guggenheim Fellowship. She is associate editor for both the *American Journal of Primatology* and *Animal Behavior*, and the author of numerous articles on animal communication and behavior. Her book, coauthored with R. M. Seyfarth, *How Monkeys See the World: Inside the Mind of Another Species* (1990) received the W. W. Howells Book Prize from the American Anthropological Association.

Twenty years ago, the search for an animal model of human language seemed to have reached an impasse. Numerous attempts to teach captive apes (usually chimpanzees) some form of artificial language had revealed that apes had a clear capacity for understanding the semantic properties of symbols, at least under the tutelage of humans. Nevertheless, there was little evidence that these same individuals could combine signs into sentence like phrases, and it began to seem rather fruitless to continue the attempt to teach animals a communicative system of which they were probably incapable (Seidenberg and Pettito 1979; Terrace et al. 1979; Ristau and Robbins 1982). Instead, a number of comparative psychologists argued, it would be more productive for future studies of nonhuman primate communication to shift their focus to two related issues: the natural communication of apes and the link between communication and cognition (Terrace and Bever 1976; Premack 1976a).

In the ensuing twenty years, the first question has hardly been addressed; we still know almost nothing about the natural communication of any ape (cf. Mitani 1996). The second has received far more attention, but studies in this area have raised almost as many questions as they have answered.

It has become clear, for example, that a wide range of animals in addition to apes can be taught by humans to use artificial labels to designate objects or properties of objects. What cognitive mechanisms, however, underlie the use of such labels? Do the labels

Many of the ideas presented in this paper were developed from discussions with C. Fisher, J. Gros-Louis, F. Hurewitz, E. Kako, P. Li, T. Mintz, J. Snedeker, and L. Wagner. Research on vervet monkeys and baboons was supported by the National Science Foundation, the National Institutes of Mental Health, the National Geographic Society, the John Simon Guggenheim Foundation, and the University of Pennsylvania. We are also grateful to the governments of the Republics of Kenya and Botswana for permission to conduct research.

map onto preexisting concepts? If so, why do the same animals not explicitly label these concepts except when tutored by humans?

Similarly, we now know that at least some species of nonhuman primates possess in their natural communicative repertoire a small number of calls that serve as semantic labels for objects. Nonetheless, these same animals never seem to create new calls or labels for objects. Why should an animal that already possesses a small number of semantic signals in its vocal repertoire be unable to create new labels for other objects and events in its environment? Why is there so little evidence for learning and modification in the natural calls of nonhuman primates and other mammals?

Finally, if animals can be taught to obey sentencelike commands by humans, why do they not also spontaneously produce sentences, and why is there no evidence for syntax in the natural communication of animals? What, in fact, is the effect of human training on the cognitive capacities of animals?

In this paper, we explore some of these questions, briefly reviewing some of the evidence and highlighting some remaining puzzles and paradoxes. We suggest that the communication of nonhuman animals lacks three features that are basic to the earliest speech of young children: a rudimentary theory of mind, the ability to generate new words, and syntax. We suggest that animals' lack of a theory of mind is the most fundamental and is causally related to the other two.

1. WHAT IS THE UNDERLYING MENTAL REPRESENTATION OF A CALL?

Under natural conditions, a number of monkey species use acoustically different calls that act to designate objects and events in the external world. These calls are functionally semantic, because they evoke the same responses from listeners as do the stimuli to which they refer. Some vocalizations, like predator alarm calls, are given in response to different classes of predators

and evoke qualitatively different responses (e.g., vervet monkey alarm calls; Struhsaker 1967; Seyfarth et al. 1980). Other calls, however, are given in the same general context and appear to function almost as synonyms, despite being acoustically distinct. Vervet monkeys, for example, have at least three acoustically different calls that are given in response to neighboring groups, and playback experiments have demonstrated that listeners treat these calls as roughly equivalent (Cheney and Seyfarth 1988, 1990b). In a similar fashion, diana monkeys appear to judge a leopard's growl, a male diana monkey's leopard alarm call, and a female diana monkey's leopard alarm call as designating the same class of danger, even though the three calls are acoustically distinct (Zuberbuhler et al. 1997).

What sorts of mental representations underlie the production and perception of these vocalizations? Do monkeys classify two calls as synonymous because they can be placed in the same conceptual category, or are they classified as similar simply because they have become associated with the same response or stimulus?

Although the intuition that words are labels for underlying mental concepts is not contested, what a concept or category actually might be has eluded philosophers since at least John Locke (see reviews by, e.g., Quine 1977; Smith and Medin 1981; Carey 1985; Keil 1989). For example, although it seems obvious that people and animals should be inclined to classify many objects in their world according to perceptual similarity, even this apparently simple criterion has proved difficult to define. Objects cannot simply be grouped into categories according to a list of necessary or sufficient features, because most objects do not have fixed essences, nor do people tend to classify objects according to strict defining features (Katz and Fodor 1963; Fodor 1975, 1994; Keil 1995). Similarly, although people often seem inclined to cluster objects around prototypical exemplars of a given class (Rosch 1973; Smith and Medin 1981; but see Armstrong et al. 1983), they nonetheless have little difficulty assigning atypical objects to

their appropriate classes; penguins, for instance, are classified as birds despite being unable to fly.

Even if it were possible to define “perceptual similarity,” this criterion would not adequately account for all conceptual categories, because people (and perhaps animals) also make functional classifications of objects based on causal theories about their underlying properties. Many concepts seem to be defined according to clusters of intuitive beliefs about how and why things work; these explanatory causal theories may be different in different domains and are often present even in very young children (Keil 1989, 1995). S. Carey (1985) has suggested that children are predisposed to apply different intuitive theories to the physical and psychological domains (see also Premack and Dasser 1991; Spelke et al. 1992). They may also attribute different causal properties to biological and nonbiological phenomena (Keil 1989).

Experimental psychologists concerned with the kinds of associations that are formed during classical and instrumental conditioning view categories from a more operational perspective. Stated loosely, objects are considered to belong to the same category if they are treated by the animal (or human) as equivalent (Wasserman and Astley 1994). Like humans, animals seem predisposed to treat perceptually similar objects as belonging to the same category (Herrstein 1985; Wasserman and Astley 1994), but pigeons and rats will treat even perceptually dissimilar stimuli as equivalent if they are associated with the same response or context (e.g., Herrstein 1985; Medin 1989; Wasserman et al. 1992). Thus, prior history of association with a common response may produce a category of functionally equivalent but physically different items (Thompson 1995).

For an animal to demonstrate true “stimulus equivalence,” it must demonstrate reflexivity (i.e., by identifying two items as “same” or “different”), transitivity (i.e., by making an inferential judgment across pairs of stimuli that share a common element), and symmetry (i.e., by recognizing that, if *A* is associated with *C*,

then *C* must be associated with *A*) (Dube et al. 1993; Fields 1993). In addition to monkeys (e.g., Wright et al. 1983; Burdyn and Thomas 1984; D'Amato et al. 1985) and apes (e.g., Premack 1976a, 1983), a number of other nonhuman mammals (e.g., sea lions: Schusterman and Kastak 1993; dolphins: Herman and Gordon 1974; Herman et al. 1989) and birds (e.g., African grey parrot: Pepperberg 1987) seem to be capable of some equivalence judgments.

Stimulus equivalence as measured by behavioral output provides a useful operational tool for examining the classification of objects by nonverbal animals, if only because behavioral responses are typically the only reliable dependent variable. The method does, however, beg a number of questions. For example, when an animal, through its responses, treats two stimuli as equivalent, how does it represent this equivalence in its mind? When pigeons are trained to discriminate between, say, slides of cats and slides of trees, does this mean that they have constructed some sort of pictorial representations of platonic cats and trees that they can actively access and compare with new exemplars (a form of declarative knowledge)? Or do they simply reflexively associate pictures of cats and trees with the same response or reward (a form of procedural knowledge)?

Another objection to the behaviorist's approach centers on its central premise: that stimuli belong to the same class when they are treated as similar. By this definition, a monkey that has been trained to sort pictures of pigs from pictures of monkeys places all monkeys into the same equivalence class. And yet a different training regime could reveal that the same subject easily distinguishes among different individual monkeys (Humphrey 1974).

Finally, behavioral responses reveal little about the mental mechanisms that underlie them. Consider, for example, the intergroup calls of vervet monkeys described earlier. On the one hand, vervets might classify these acoustically different calls as synonymous because the calls evoke the same mental concept (i.e., an

intruding group), in much the same way that humans judge different sounding words according to their meaning. On the other hand, the calls could be judged as equivalent simply because they are associated with the same stimulus and/or response (Thompson 1995).

This explanatory impasse can be partially resolved by considering other, complementary sorts of evidence. For example, in captivity monkeys readily learn to classify objects according to sameness or oddity (e.g., Davis et al. 1967; Burdyn and Thomas 1984), suggesting at the very least that free-ranging vervets are capable of forming relative class concepts and comparing calls according to their meanings. Equally important, under natural conditions intergroup calls do not consistently evoke the same responses, nor are they always elicited by the same stimuli. Depending on the context in which they occur, the same call can evoke a number of different responses, ranging from apparent indifference to hostile chases and fights. Similarly, the call can be given to single individuals or entire groups. Vervets also use intergroup calls to mark the status of immigrant males, giving intergroup calls to a male when he first enters a group and gradually shifting to other call types as he becomes more integrated into the social structure (Cheney and Seyfarth 1990b).

Observations such as these suggest that vervets' intergroup calls designate a type of event rather than a specific behavioral response or stimulus. Of course, the precise content of vervets' mental representations of intergroup encounters remains elusive, just as the precise content of most human concepts remains elusive. It seems likely, however, that these representations consist of more than reflexive responses to particular vocal stimuli.

2. WHY DO ANIMALS HAVE SO FEW LABELS FOR OBJECTS AND EVENTS?

Even if it were possible to specify the nature of the concept that underlies, for example, a vervet monkey's eagle alarm call,

we would still be left with an enigma: why do monkeys (and other animals) apparently have so few semantic labels? Vervet monkeys have different calls that function to designate a variety of events, including different classes of predators, neighboring groups, and the initiation of group movement. However, it is easy to think of many other events and objects that monkeys appear not to label with calls. For example, there is both observational and experimental evidence that monkeys recognize the close associates of other group members (e.g., Cheney and Seyfarth 1980; Dasser 1988; reviewed in Cheney and Seyfarth 1990b). Nonetheless, they have no vocal labels for different kin classes such as "mother" or "offspring" or even "closely bonded." Similarly, monkeys and apes clearly recognize other individuals by face and voice, and yet there is no evidence that they ever tag each other with names.

There is at present very little evidence for vocal learning in nonhuman primates. Indeed, with the exception of cetaceans, no mammals seem to learn vocal repertoires or adopt local dialects as song birds do (see reviews by Marler 1990; Snowdon 1990; Janik and Slater 1996; Snowdon and Hausberger 1997). Infant vervet monkeys, for example, seem innately predisposed to give alarm calls with the acoustic features of adult eagle alarms in response to birds, and throughout sub-Saharan Africa vervets give acoustically similar calls in response to raptors (Seyfarth and Cheney 1997). Even when monkeys are reared in environments different from the ones they would normally experience, call production seems to be relatively inflexible. For example, in one experiment in which infant Japanese and rhesus macaques were cross-fostered into groups of the opposite species, there was no evidence of vocal modification. Cross-fostered juveniles continued to give species-typical calls even in contexts in which their adoptive mothers and peers gave acoustically different calls (Owren et al. 1993; see also Newman and Symmes 1982 for similar data on squirrel monkeys).

This is not to say that all aspects of vocal learning are innate and inflexible. Although monkeys seem predisposed to give certain

sorts of calls in particular contexts, both vocal usage and call comprehension appear to involve some learning. For example, although the cross-fostered Japanese and rhesus macaques in the study just mentioned failed to modify their vocalizations to match their adoptive peers and mothers, they did learn to recognize and respond to their adoptive mothers' calls, and vice versa (Seyfarth and Cheney 1997). Similarly, infant vervets are initially quite indiscriminate about the sorts of aerial objects that elicit eagle alarm calls, and they often respond inappropriately to the alarm calls of others. Over a period of several years, however, they gradually learn to restrict their eagle alarm calls to the few raptor species that pose a threat, and they also learn the correct response to different alarm calls (Seyfarth and Cheney 1986).

Why should a monkey that can learn to associate a particular call with a given species of predator nonetheless be unable to learn to produce a new vocalization? The apparent inability of vervets and other monkeys to create new calls for objects in their environment is all the more paradoxical given the fact that many species of mammals, including not only apes but also sea lions and dolphins (and, in the home, dogs and cats), can be taught to associate hundreds of artificial sounds and symbols with objects and events, including names for other individuals.

To address this puzzle, it may help to speculate for a moment about the conditions that may be necessary for a new word or symbol to be adopted by a community. Imagine a society composed of two individuals, Mort and Stanley. One day, Mort sees a butterfly for the first time and utters a new sound while looking at it: "Kipepeo." Stanley observes Mort and soon learns that when Mort says "kipepeo," he means something like *butterfly*. This sort of associative learning is quite within the capabilities of many animals; in fact, it is the method typically adopted by humans when they teach captive animals artificial signs for objects, at least in the initial stages (Premack 1976b; Savage-Rumbaugh 1986; Schusterman et al. 1993).

The adoption of *kipepeo* by others, however, may entail a more complex process. One method might involve a process similar to instrumental learning. For example, Mort's use of *kipepeo* could facilitate its use by Stanley, much in the way that many species of animals are drawn to manipulate objects they have observed conspecifics manipulating (Fiorito and Scotto 1992; Zentall 1996). Alternatively, Stanley might in some way copy Mort whenever both of them saw a butterfly. Eventually, Stanley would learn that his use of *kipepeo* produced a given response in Mort, and the two would arrive at a shared convention. In either case, the spread of the word through the community would be slow and subject to error.

Instead, efficient and widespread adoption of a new word would seem to require that both speaker and listener attribute intention and beliefs to one another (Grice 1957; Jackendoff 1994). In D. C. Dennett's (1995) terms, Stanley must adopt the intentional stance to determine why Mort says "kipepeo." According to this scenario, Stanley recognizes that when Mort says "kipepeo," he probably means *butterfly*. As a result, the next time Stanley wishes to communicate with Mort about a butterfly, he says "kipepeo," reasoning that Mort will recognize that Stanley also means *butterfly* when he says this word.

It seems possible, then, that some sort of rudimentary theory of mind (Premack and Woodruff 1978) might be necessary for the learning of words and language. If true, this hypothesis might explain the lack of vocal learning by monkeys, because all evidence to date suggests that monkeys cannot attribute mental states to others (see reviews by Cheney and Seyfarth 1990b; Povinelli 1993; Tomasello and Call 1997).

In contrast, word learning in even very young children seems to be accompanied by primitive mental state attribution. Clearly, young children of one and two years of age do not have a fully developed theory of mind, in the sense that they attribute false beliefs to others (Astington et al. 1988; Wellman 1990; Perner

1991). By the age of one year, however, they already seem to understand that words can be mapped onto objects and actions in the world (Golinkoff et al. 1994; Hirsh-Pasek and Golinkoff 1996). Crucially, this understanding seems to be accompanied by a form of “social referencing,” in which the child uses other people’s direction of gaze, gestures, and emotions to appraise a situation.

As early as six months of age, infants are capable of attending to their mothers’ direction of gaze to infer where to look, and by the age of eighteen months they are able to guess both the direction and the location of an adult’s focus of gaze, even when this is outside their own visual field (Butterworth and Jarrett 1991). Infants at this age also actively attend to the speaker’s gaze and focus of attention when inferring the referent of the speaker’s utterance (Baldwin 1993a, 1993b), as if they have developed some tacit understanding that gaze and attention are a reflection of underlying knowledge (Tomasello 1996a).

Similarly, around the age of one year infants begin to use gestures and sounds to recruit adults’ attention. In pointing toward a desired object, they will often turn to the addressee as if to check that the message has been received, and they begin to repeat and alter sounds or gestures that have been interpreted incorrectly (Golinkoff 1986; Bretherton 1992). One-year-old children also seem capable of inferring the goals and intentions of adults, even when adults perform an intentional act incorrectly (Meltzoff 1995). Finally, by the age of two years they begin to distinguish between ignorance and knowledge in others and adjust their speech accordingly (O’Neill 1996).

Through imitation, declarative gestures, and speech, therefore, young children demonstrate that they view adults as intentional beings. Their ability to compare another’s perceptual state with their own forms the basis of a social referencing system that appears to be integral to early word learning.

It should be noted that although the acquisition of knowledge through joint attention involves the ability to attend to gaze direc-

tion, this by itself is by no means sufficient. People with autism, for example, seldom point to others, monitor other people's gazes to gain information, or bring objects to other people's attention, even though they are capable of attending to other people's direction of gaze (Baron-Cohen 1995; Baron-Cohen et al. 1995). Gaze is recognized as a behavioral act, it seems, but not as a reflection of underlying beliefs and knowledge.

In this respect, monkeys seem very different from young children and more like many people with autism. Several neurological studies have suggested that monkeys and other mammals are very sensitive to eye contact and gaze (Perrett et al. 1987; Perrett and Emery 1994; Walsh and Perrett 1994). Under natural conditions, monkeys also readily follow the gazes of others. However, they do not use gazes or gestures like pointing to attract other individuals' attention to themselves or to some third individual or object in the environment (Anderson et al. 1995, 1996). Similarly, although monkeys can be trained to point and to attend to pointing by humans, they appear to recognize pointing only as an indication of a predictable event, and not as a representation of intent. Thus, for example, a rhesus macaque that has been trained to point to acquire food will nonetheless fail to recognize the significance of pointing in others. Conversely, a monkey that has been taught to respond to a human's pointing will not itself gesture or point to acquire food (Povinelli, Parks, and Novak 1992; Hess et al. 1993; see also Anderson et al. 1995, 1996). Finally, monkeys do not appear to make adjustments to messages that were received or interpreted inaccurately, except to escalate a display. They do not, for example, attempt to correct others or themselves (Cheney and Seyfarth 1990b).

This is not to say that monkeys never direct their calls or behavior toward specific other individuals; clearly they do. The "reconciliatory" grunts given by dominant female baboons, for example, seem deliberately directed at their former victims. Moreover, through their behavior, these victims act as if they interpret

the calls as being directed at themselves (Cheney and Seyfarth 1997). Similarly, although monkeys rarely attempt to recruit other individuals' attention through gaze or gesture, they do use gaze to target opponents and to recruit other individuals' support in aggressive alliances. Monkeys also seem to recognize that displays and facial expressions are ineffective without some degree of eye contact. They rarely display at another individual if that individual's back is turned to them, and they often seem to take deliberate steps to make or avoid eye contact with others (e.g., Hall and Devore 1965; Zeller 1987; Smuts and Watanabe 1990).

The difference between young human children and monkeys may be due to the fact that monkeys call and look at each other in order to influence each other's behavior, whereas children do so in order to influence their attention or knowledge. All observations and experiments conducted to date suggest that monkeys are incapable of recognizing that other individuals gain knowledge when they look at something (Cheney and Seyfarth 1990b; Povinelli, Parks, and Novak 1992; Anderson et al. 1995, 1996).

Indeed, it is debatable whether even chimpanzees can recognize the link between seeing and knowing, or whether they are capable of manipulating or recruiting attention in the way that young children do. Like monkeys, chimpanzees will actively seek to attract other individuals' attention. They also readily follow other individuals' gazes and attend more to individuals whose eyes are open than to those whose eyes are shut (Povinelli and Eddy 1996a, 1996b). However, they may not understand seeing as a mental event or recognize that a gaze has intentional significance. For example, although chimpanzees will refrain from begging or gesturing to a human whose back is turned, they will nonetheless gesture to humans whose eyes have been blindfolded (Povinelli and Eddy 1996b).

In one experiment in which captive chimpanzees had to distinguish between a knowledgeable and an ignorant human informer in order to acquire food, three of four subjects eventually learned

to choose the knowledgeable informer in a significant number of trials (Povinelli et al. 1990). The chimpanzees' performance certainly exceeded that of rhesus macaques, who never learned to distinguish between the two informants at all, and who had to be trained to respond to pointing (Povinelli, Parks, and Novak 1992). Curiously, however, even the successful chimpanzees continued to select the ignorant informer in approximately 30 percent of trials, suggesting that their choices may have been based on some contingency-based rule rather than on knowledge of the causal relation between seeing and knowing. In this respect, the chimpanzees' "theory of mind" seems qualitatively different from that of human children, who seem predisposed from an early age to view other individuals as intentional beings with goals and beliefs.

3. WHY DOES THE NATURAL COMMUNICATION OF MONKEYS AND APES LACK SYNTAX?

The inability of monkeys and perhaps also apes to recognize the mental mechanisms that underlie communicative acts may partially explain the absence of syntax in their vocalizations. Words are more than just labels for concepts (whatever a concept is); they can also be grouped into different categories according to their syntactic properties. Words acquire additional meaning through their relation to other words and their roles as modifiers, nouns, and verbs (Bever 1970; Crain and Fodor 1985; Dowty 1991; Pinker 1994).

As described earlier, at least some of the sounds produced by monkeys are functionally semantic. By contrast, there is no evidence in any nonhuman primate for even the most rudimentary form of syntax. Although monkeys often utter calls in bouts, there appears to be no syntactical structure to these bouts. Instead, sequences of calls tend to consist of either the same call repeated a number of times (Cheney and Seyfarth 1990b) or of the pairing of two calls typically associated with different emotional states to express an intermediate state (Robinson 1984).

Because they lack syntactic properties, it is almost impossible to determine the precise semantic content of a signal like a vervet's leopard alarm call or a baboon's contact bark. A leopard alarm, for example, cannot really be described as a command to action (e.g., "Run into the trees") because not all vervets run into trees upon hearing the call, and vervets already in trees will also give this call if they spot a leopard. Similarly, the call cannot really be described as a noun ("leopard" or "carnivore") because it consistently evokes a flight response from at least some listeners. Instead, it seems that the vervet's leopard alarm call is best described as a proposition: a single utterance or thought that simultaneously incorporates a subject and a predicate (e.g., Bever 1970; Gleitman 1991; Stillings et al. 1995).

Vervet alarm calls certainly seem to be simultaneously eventish and objectish, in that they incorporate both reference to an object and a disposition to behave toward that object in a particular way. They refer to a particular sort of immediate danger, and they function to designate particular classes of predators. There is no evidence, though, that a leopard alarm call can be modified to elaborate upon the characteristics of the leopard currently in question. Through repetition and changes in amplitude (both of which seem to carry prosodic information), alarm calls can serve to inform others of the immediacy of danger. They cannot, however, specify whether a leopard is big or small, sleeping or stalking, in a tree or on the ground.

In this respect, vervet alarm calls recall the first utterances of very young children, who often seem to have propositional attitudes in mind when they utter single words (or "holophrases"; Dore 1974). When a one-year-old child says a word like *ball*, for example, it often appears that she is doing more than simply denoting an object. Depending upon the context of its use, the word may function as a request ("Give me the ball") or as a declarative comment ("Look at my ball") (Shipley et al. 1969). In the same

way, a vervet's leopard alarm call can function both to designate a particular sort of animal and to signal an escape response.

The linguistic capacities of even one-year-old children probably surpass those of vervets, however, because even at the one-word stage children not only comprehend sentences but are also extremely sensitive to the syntactical relations among words (Bloom 1970; Dore 1974; Barrett 1982; Hirsh-Pasek and Golinkoff 1996). For example, children at the one- or two-word stage clearly use grammatical structures (or "syntactic bootstrapping") to infer the meaning of words (Brown 1973; Pinker 1984, 1989; Gleitman 1990), and they will respond differently to a grammatically well-formed command than to an ill-formed one (Shipley et al. 1969). Unlike monkeys, children use one-word utterances in different contexts, and they also use gestures and intonation to add meaning to their utterances (Barrett 1982; Morford and Goldin-Meadow 1992).

How do we explain the apparent lack of syntax in the vocal communication of nonhuman primates and other animals? One possible explanation is that animals simply lack the conceptual ability to recognize argument structure—that is, they fail to see that an event can be described as a linear sequence in which an agent performs some action on an object (e.g., *Amy threatens Betty*, as opposed to *Betty threatens Amy*). Similarly, they may simply be unable to represent descriptive modifiers (e.g., a *big* leopard as opposed to a *small* one), or prepositions that specify locations (e.g., a leopard *in* a tree, as opposed to one *on* the ground). This, however, seems unlikely.

Although the definitive experiments have not yet been conducted, it seems probable that animals are capable of thinking, as it were, in sentences. Monkeys certainly act as if they have expectations about the direction and outcome of social interactions. For example, baboon females appear to recognize the factors that cause one individual to give submissive vocalizations to another, and they

respond strongly to interactions that appear to violate the existing dominance hierarchy (Cheney et al. 1995). Through their responses, in other words, they act as if they know the difference between an interaction in which *A* supplants *B* and one in which *B* supplants *A*. Similarly, when watching videos of behavioral interactions among humans, captive chimpanzees can learn (though only after considerable training) to label one event as *A approaches B*, and another as *B approaches A* (Itakura and Matsuzawa 1993). Experiments with captive tamarins also suggest that monkeys respond more strongly to videos of causally anomalous events than causally consistent ones (Hauser in press). Finally, there is evidence that particular areas in the temporal cortex of rhesus macaques are more responsive to causally related movement patterns than to movements that are merely contiguous (Perrett et al. 1990).

In distinguishing between an event that violates the current dominance hierarchy from one that does not, a female baboon acts as if she has knowledge of argument structure. It is possible, however, that this knowledge remains tacit, and that she does not explicitly designate sequences of events in terms of their component parts. In any case, even if monkeys and apes do mentally tag events with syntactical properties (who does what to whom), they certainly fail to map these tags onto a communicative system in any stable or predictable way. By contrast, even very young children seem predisposed to order words sequentially, such that agents precede actions and actions precede objects (e.g., Slobin and Bever 1982; Pinker 1989; Naigles et al. 1992).

The apparent failure of free-ranging monkeys to map mental argument structures onto a linguistic code becomes even more puzzling when we consider the success with which different animal species have been taught by humans to comprehend phrases that differ according to their use of specific nouns, verbs, and modifiers.

The various “ape language” projects have demonstrated clearly that captive apes can learn to comprehend and even produce phrases that differ according to agent, action, or modifier. In addi-

tion to using symbols for objects, chimpanzees readily acquire signs for numbers, color, and properties, and they use these modifiers in the appropriate contexts (Premack 197a, 1986; Matsuzawa 1985; Savage-Rumbaugh 1986; Boysen 1996). The bonobo Kanzi is able to understand commands that include nouns, verbs, and modifiers with the same accuracy as a two-year-old child (Savage-Rumbaugh et al. 1993).

Apes, moreover, are not unique in their ability to learn to tag symbols with syntactic properties. The African grey parrot Alex, for example, was taught to label objects with modifiers like color, shape, and quantity (Pepperberg 1981). He could also identify modifiers within subsets of modifiers to answer question like "*What color 4-cornered wood?*" (Pepperberg 1992). In so doing, Alex behaved as if his knowledge of words was to some degree category-based.

Similarly, L. M. Herman and his colleagues taught two dolphins to obey sentencelike strings of commands that differed according to the sorts of modifiers, actions, or objects that were specified. Some modifiers were even relational (e.g., left and right). Tests with novel "sentences" suggested that the dolphins had some understanding of the words' syntactical categories; even if they had never encountered a particular set of words together before, they could relate them successfully in a novel command (Herman 1987; Herman et al. 1984; Herman, Kuczaj, and Holder 1993; Herman, Pack, and Morel-Samuels 1993; Kako in prep.). Sea lions have been taught to obey commands of similar complexity, as well as the use of relational modifiers (Schusterman and Krieger 1986; Gisiner and Schusterman 1992).

In each of these cases, language-trained animals act as if they imbue signs not only with specific meanings but also with syntactical properties that relate in a consistent manner to other signs. To date, however, there has been no definite test of this hypothesis. One such test might be to insert a novel sign into the position normally occupied by a verb. If the animal tagged this sign with a

syntactical property, it should treat it as something requiring an action. Such syntactical bootstrapping is a device commonly used by children to deduce the meaning of words (Gleitman 1990; Pinker 1994). Future investigations of the linguistic capacities of language-trained animals should also search for other crucial attributes of human syntax, including the use of closed class items like prepositions (Kakoin prep.). Until then, it will remain a matter of debate whether many language-trained animals have even acquired knowledge of the semantic properties of signs, as opposed to having learned simply the stimulus equivalence relation between a sign and its referent (Schusterman and Gisiner 1989).

Similarly, although language-trained animals may be relatively proficient in the comprehension of phrases, it is doubtful whether even language-trained apes can produce phrases with any consistent syntactic structure (Seidenberg and Pettito 1979; Terrace et al. 1979; Ristau and Robbins 1982). P. M. Greenfield and E. S. Savage-Rumbaugh (1993) have contended that Kanzigives syntactic structure to his signs by combining lexicons with gestures like pointing. Because he typically places the lexicon before the gesture, however, it could be argued that Kanzi's combinations fail to show the same organizational structure as children's two-word utterances (Kako in prep.). Children at this stage will serially order words according to their propositional role (DeVilliers and DeVilliers 1973). Through such ordering they can produce "sentences" that distinguish, for example, between "Susan tickle (me)" and "(Me) tickle Susan." It is not clear whether Kanzi can do the same.

Assuming for the moment, however, that animals as diverse as parrots, sea lions, and bonobos can be taught to comprehend and distinguish among modifiers, actions, and objects, why do their natural vocal signals not reflect this ability? Perhaps it relates, once again, to their apparent lack of a theory of mind.

For example, although vervet monkeys, like many other animals, vary their rates of alarm calling depending upon the presence and composition of their audience, they do not act deliberately to

inform ignorant individuals more than knowledgeable ones (Cheney and Seyfarth 1990a, 1990b). Similarly, they do not attempt to correct or rectify false beliefs in others, and they do not instruct others in the correct usage or response to calls (Seyfarth and Cheney 1986). Because vervets are unable to distinguish between what they know and what others know, they may fail to recognize that ignorant individuals have to have events explained and described to them. As a result, they may not understand that there is a need to specify whether a leopard is in a tree or on the ground. Perhaps for the same reason, vervets do not comment upon events of the past or signal about things in their absence.

Monkeys' calls, therefore, appear to reflect the knowledge the signaler has rather than the knowledge the signaler intends his audience to acquire (Cheney and Seyfarth 1990b, 1996). Indeed, in many cases the meaning and function of a call from the listener's perspective may differ considerably from that of the signaler's (Marler 1961). For example, dominant female baboons often grunt to their victims shortly after fighting with them. These grunts change the victim's subsequent behavior, making her more likely both to approach her former opponent and to tolerate her former opponent's approaches (Silk et al. 1996; Cheney and Seyfarth 1997). Whether the dominant female intends to reconcile with her former victim, however, is debatable. Instead, it seems more likely that female baboons grunt to victims simply because they now wish to interact with them. Through past experience and perhaps also through observing the interactions of others, victims learn that grunts signal a low probability of attack, with the result that the calls come to serve a reconciliatory function (Cheney and Seyfarth 1996, 1997).

Similarly, baboons often utter loud "contact" barks when moving through wooded areas. Because these barks are clumped in time, it often appears as if individuals are exchanging barks in order to inform each other of their location. It seems unlikely, however, that baboons give contact barks with the intent of ex-

changing information, because baboons tend to give contact barks only when they themselves are peripheral or separated from others. They seldom answer the contact barks of others when they are in the center of the group progression and at no risk of becoming separated themselves (Cheney et al. 1996; Cheney and Seyfarth 1996). Nonetheless, the barks function as contact calls because they permit listeners to deduce the group's location and direction of travel. In both cases, the listener extracts rich, even semantic, information from a signaler who may not, in the human sense, have intended to provide it.

A variety of evidence suggests, therefore, that a theory of mind might be crucial not only to many of the attributes that we consider critical to human culture —such as teaching, informing, empathy, and deceit —but also to syntax and the adoption of new words.

4. DO THESE GENERALIZATIONS ALSO APPLY TO APES?

The argument that linguistic capacity is ultimately linked to at least a rudimentary theory of mind may account for the lack of syntax and word learning in monkeys, but does it apply equally to apes? To this point in the discussion, we have considered monkeys and apes together, at least in part because almost nothing is known about the communication of apes under natural conditions. But this lumping of apes and monkeys may be unwarranted if apes have the capacity to attribute mental states to others. This issue, in fact, is a matter of some contention. While there are those who maintain that there are greater cognitive differences (specifically with reference to a theory of mind) between monkeys and apes than between apes and humans (Savage-Rumbaugh and Lewin 1994; Byrne 1995), it is also argued that no cognitive tests have as yet demonstrated a qualitative difference between monkeys and apes in the capacity to attribute mental states to others (Tomasello and Call 1997; Heyes in press; Tomasello in press).

There is some evidence that chimpanzees learn more easily than monkeys to recognize the goals and motives of others. In captivity, they seem better than monkeys at assuming another individual's role in a cooperative task and at recognizing intentional gestures, such as pointing (Povinelli et al. 1900; Povinelli, Nelson, and Boysen 1992; Povinelli, Parks, and Novak 1992). They also seem better at emulating others. When watching a demonstrator use a tool, chimpanzees, unlike monkeys, readily learn its use and function. However, unlike children, they do not copy the precise motor patterns or methods of the demonstrator (Nagell et al. 1993). As a result, it remains unclear whether the difference in performance between chimpanzees and monkeys stems from chimpanzees' greater capacity to comprehend the goals and intentions of others or from their proficiency in recognizing cause-effect relations (Tomasello et al. 1987; Limongelli et al. 1995; Povinelli and Eddy 1996; Tomasello 1996a; Tomasello and Call 1997).

There is at present little evidence from natural populations of chimpanzees that apes take into account their audience's mental states when communicating with one another. For example, chimpanzees do not appear to adjust their loud calls to inform ignorant individuals about their own location or the location of food (Mitani and Nishida 1993; Clark and Wrangham 1994; Mitani 1996). Similarly, although chimpanzees certainly differ from monkeys in the variety and frequency of tool use (McGrew 1994), there is no evidence that chimpanzees learn to use tools by actively imitating or instructing one another (Tomasello 1996b; Tomasello and Call 1997). Finally, although there are more anecdotal examples of deception in apes than in monkeys (Byrne 1995), it is unclear whether this difference stems from apes' capacity to recognize the causal relation between behavior and knowledge or from their greater ability to recognize and act upon observed contingencies. In fact, as discussed earlier, tests on captive chimpanzees indicate that apes do not easily learn to recognize the relationship

between perception and knowledge (Povinelli et al. 1990; Povinelli and Eddy 1996b).

This is not to say that there are no important cognitive differences between monkeys and apes. First, as mentioned above, chimpanzees seem better than monkeys at emulating the actions of others and at recognizing causal relations between tools and their functions (Visalberghi and Limongelli 1994; Limongelli et al. 1995; Tomasello and Call 1997). Second, apes seem better at making abstract relational judgments involved in tasks like analogical reasoning (e.g., a big circle has the same relation to a small circle as a big square has to a small square) (Premack 1983; Thompson 1995; Thompson and Oden 1995). Finally, a variety of evidence suggests that language-trained apes come to view signs as true symbols for things rather than simply as items that are associated with certain objects (Premack 1976b, 1986; Savage-Rumbaugh 1986; Boysen 1996). Thus, for example, language-trained chimpanzees appear to recognize that a sign can designate an object, but not vice versa. Whether monkeys are also capable of recognizing this distinction is unknown, because the necessary tests have not been conducted. It also remains to be seen whether chimpanzees recognize this distinction in their natural communication.

5. WHAT IS THE EFFECT OF HUMAN TRAINING ON THE COGNITIVE CAPACITIES OF ANIMALS?

To date, most of the evidence that the cognitive abilities of chimps differ in significant ways from those of monkeys comes from chimpanzees that have had prolonged contact and/or training with humans. In fact, there may be as many differences between the performance of human-“enculturated” chimpanzees and “natural” chimpanzees as between apes and monkeys in general. In one experiment specifically designed to test the effect of human enculturation, M. Tomasello et al. (1993) compared the imitative abilities of chimpanzees raised by humans (but not language-

trained), chimpanzees raised by their own mothers, and two-year-old children. Each subject was shown a number of novel actions and scored according to whether it imitated the action of the demonstrator. Mother-reared chimps did not, whereas human-reared chimpanzees and children did. In another experiment, investigators examined the use of joint attention by chimpanzees and children when learning to imitate a task involving novel objects. Again, children and enculturated chimps looked back and forth from the object to the demonstrator and used gestures to direct the demonstrator's attention, whereas mother-raised chimps did not (Carpenter et al. 1995). Similarly, only chimpanzees that have been trained to use tokens as symbols are able to solve match-to-sample tasks that explicitly require them to judge relations between relations. Naïve chimpanzees can perceive these relations, but this knowledge seems to remain tacit (Thompson and Oden 1995).

Does exposure to humans somehow enhance chimpanzees' cognitive capacities? Human trainers actively engage their chimpanzee subjects' attention when interacting with them or instructing them in the use of signs. As a result, apes raised in the context of human culture and instruction may come to view humans as intentional agents who have goals and motives (Tomasello and Call 1997). It is also possible, however, that exposure to humans simply familiarizes chimpanzees with human artifacts and training regimes, which in turn facilitates learning. If the development of even a rudimentary theory of mind requires exposure to tutors who themselves already possess a theory of mind, it is difficult to imagine how the ability to attribute mental states to others would evolve in the first place (Povinelli 1996).

6. SUMMARY

It seems fruitless to continue to speculate about the significance of apes' ability to learn artificial signs or gestures when so little is known about their natural communication. While it is sometimes

asserted that chimpanzees' and bonobos' gestures may convey more information than their vocalizations (Savage-Rumbaugh et al. 1996; Tomasello in press), these assertions are based on intuition rather than fact; almost nothing is known about the possible "semantic" content of these species' calls (Mitani 1996). Similarly, nothing is known about the development of communicative behavior in any of the great apes. Although the acquisition of tool use by young chimpanzees appears to require observational learning and practice (Goodall 1970; Boesch 1991), it is as yet unclear if any form of joint attention or social referencing occurs in such learning, or whether similar learning processes might occur in the context of communication.

Violating our own injunction, we offer here one speculative hypothesis that may be a spur to further research. The admittedly scanty evidence assembled to date suggests that the communication of nonhuman animals lacks three features that are abundantly present in the earliest words of young children: a rudimentary theory of mind, the ability to generate new words, and syntax. We suggest that the absence of all three features is not accidental, and that the lack of one (theory of mind) may be causally related to the lack of the others (words and syntax). Because they cannot attribute mental states to one another and are unaware of the relation between behavior and beliefs, monkeys and perhaps also apes are considerably less adept than young children at recognizing the intentions of others and learning new behavior from others. For the same reason, they do not go out of their way to inform others, to instruct others, or to describe and comment upon events in the world. This failure stems not from the inability to recognize or attend to events, but from the inability to recognize that not all individuals share the same knowledge about these events.

Despite their lack of a theory of mind, monkeys nonetheless seem to view other individuals as behaving, animate beings with predictable actions and relationships. In their social interactions, monkeys act as if they regard other individuals as entities that

cause one another to behave in predictable ways; they also seem to recognize that social interactions have predictable outcomes. Indeed, if monkeys lacked the ability to distinguish *A supplants B* from *B supplants A* — that is, if they lacked a rudimentary social syntax — they could hardly survive in their group. Again, however, we know almost nothing about the forms of causal reasoning that might underlie these social inferences. Another challenge for the future will be to identify the kinds of social understanding that are possible in the absence of a theory of mind.

REFERENCES

- Anderson, J. R., M. Montant, and D. Schmitt. 1996. "Rhesus Monkeys Fail to Use Gaze Direction as an Experimenter-Given Cue in an Object-Choice Task." *Behav. Proc.* 37: 47–55.
- Anderson, J. R., P. Sallaberry, and H. Barbier. 1995. "Use of Experimenter-Given Cues during Object-Choice Tasks by Capuchin Monkeys." *Anim. Behav.* 49: 201–8.
- Armstrong, S. L., L. R. Gleitman, and H. Gleitman. 1983. "What Some Concepts Might Not Be." *Cognition* 13: 263–308.
- Astington, J. W., P. L. Harris, and D. R. Olson (eds.). 1988. *Developing Theories of Mind*. Cambridge: Cambridge University Press.
- Baldwin, D. 1993a. "Early Referential Understanding: Infants' Ability to Recognize Referential Acts for What They Are." *Develop. Psych.* 29: 832–43.
- . 1993b. "Infants' Ability to Consult the Speaker for Clues to Word Reference." *J. Child Lang.* 20: 395–418.
- Baron-Cohen, S. 1995. *Mindblindness: An Essay on Autism and Theory of Mind*. Cambridge, Mass.: MIT Press.
- Baron-Cohen, S., R. Campbell, A. Karmiloff-Smith, and J. Grant. 1995. "Are Children with Autism Blind to the Mentalistic Significance of Gaze?" *Brit. J. Develop. Psych.* 13: 379–98.
- Barrett, M. D. 1982. "The Holophrase Hypothesis: Conceptual and Empirical Issues." *Cognition* 11: 47–76.
- Bever, T. G. 1970. "The Cognitive Basis for Linguistic Structures." In *Cognition and the Development of Language*, ed. J. R. Hayes. New York: Wiley.

- Bloom, L. 1970. *Language Development: Form and Function in Emerging Grammars*. Cambridge, Mass.: MIT Press.
- Boesch, C. 1991. "Teaching in Wild Chimpanzees," *Anim. Behav.* 41: 530–32.
- Boysen, S. T. 1996. "Representation of Quantities by Apes." In *Advances in the Study of Behavior*, vol. 26, ed. P. J. B. Slater, J. S. Rosenblatt, C. T. Snowdon, and M. Milinski. San Diego, Calif.: Academic Press.
- Bretherton, I. 1992. "Social Referencing, Intentional Communication, and the Interfacing of Minds in Infancy." In *Social Referencing and the Social Construction of Reality in Infancy*, ed. S. Feinman. New York: Plenum Press.
- Brown, R. 1973. *A First Language: The Early Stages*. Cambridge, Mass.: Harvard University Press.
- Burdyn, L. E., and R. K. Thomas. 1984. "Conditional Discrimination with Conceptual Simultaneous and Successive Cues in the Squirrel Monkey (*Saimiri sciureus*)." *J. Comp. Psych.* 98: 405–13.
- Butterworth, G., and N. Jarrett. 1991. "What Minds Have in Common Space: Spatial Mechanisms Serving Joint Visual Attention in Infancy." *Brit. J. Develop. Psych.* 9: 55–72.
- Byrne, R. W. 1995. *The Thinking Ape: Evolutionary Origins of Intelligence*. New York: Oxford University Press.
- Carey, S. 1982. "Semantic Development: The State of the Art." In *Language Acquisition: The State of the Art*, ed. E. Wanner and L. R. Gleitman. Cambridge: Cambridge University Press.
- . 1985. *Conceptual Change in Childhood*. Cambridge, Mass.: MIT Press.
- Carpenter, M., M. Tomasello, and E. S. Savage-Rumbaugh. 1995. "Joint Attention and Imitative Learning in Children, Chimpanzees, and Enculturated Chimpanzees." *Soc. Develop.* 4: 217–37.
- Chency, D. L., and R. M. Seyfarth. 1980. "Vocal Recognition in Free-Ranging Vervet Monkeys." *Anim. Behav.* 28: 362–67.
- . 1988. "Assessment of Meaning and the Detection of Unreliable Signals in Vervet Monkeys" *Anim. Behav.* 36: 477–86.
- . 1990a. "Attending to Behaviour versus Attending to Knowledge: Examining Monkeys' Attribution of Mental States." *Anim. Behav.* 40: 742–53.
- . 1990b. *How Monkeys See the World: Inside the Mind of Another Species*. Chicago: University of Chicago Press.

- . 1996. "Function and Intention in the Calls of Nonhuman Primates." *Proc. Brit. Acad.* 88: 59–76.
- . 1997. "Reconciliatory Grunts by Dominant Female Baboons Influence Victims' Behavior." *Anim. Behav.* 54: 409–18.
- Cheney, D. L., R. M. Seyfarth, and R. A. Palombit. 1996. "The Function and Mechanisms Underlying Baboon Contact Barks." *Anim. Behav.* 52: 507–18.
- Cheney, D. L., R. M. Seyfarth, and J. Silk. 1995. "The Responses of Female Baboons (*Papi cynocephalus ursinus*) to Anomalous Social Interactions: Evidence for Causal Reasoning?" *J. Comp. Psych.* 109: 134–41.
- Clark, A. P., and R. W. Wrangham. 1994. "Chimpanzee Arrival Pant-Hoots: Do They Signify Food or Status?" *Int. J. Primatol.* 15: 185–205.
- Crain, S., and J. Fodor, 1985. "How Can Grammars Help Parsers?" In *Natural Language Parsing: Psychological, Computational, and Theoretical Perspectives*, ed. D. Dowty, L. Karttunen, and A. Zwicky. Cambridge: Cambridge University Press.
- D'Amato, M. R., D. P. Salmon, and M. Colombo. 1985. "Extent and Limits of the Matching Concept in Monkeys." *J. Exp. Psych. Anim. Beh. Proc.* 11: 35–51.
- Dasser, V. 1988. "A Social Concept in Java Monkeys." *Anim. Behav.* 36: 225–30.
- Davis, R. T., R. W. Leary, D. A. Stevens, and R. F. Thompson. 1967. "Learning and Perception of Oddity Problems by Lemurs and Seven Species of Monkeys." *Primates* 8: 311–22.
- Dennett, D. C. 1995. *Darwin's Dangerous Idea: Evolution and the Meaning of Life*. New York: Simon and Shuster.
- DeVilliers, J. G. and P. A. DeVilliers. 1973. "Development of the Use of Word Order in Comprehension." *J. Psycholing. Res.* 2: 331–41.
- Dore, J. 1974. "Holophrases, Speech Acts and Language Universals." *J. Child Lang.* 2: 21–40.
- Dowty, D. 1991. "Thematic Proto-Roles and Argument Selection." *Language* 67: 547–619.
- Dube, W. V., W. J. McIlvaine, T. D. Callahan, and L. T. Stoddard. 1993. "The Search for Stimulus Equivalence in Nonverbal Organisms." *Psych. Rec.* 43: 761–78.
- Fields, L. 1993. "Foreword: Special Issue on Stimulus Equivalence." *Psych. Rec.* 43: 543–46.

- Fiorito, G., and P. Scotto. 1992. "Observational Learning in *Octopus Vulgaris*." *Science* 256: 545-47.
- Fodor, J. A. 1975. *The Language of Thought*. New York: Crowell Press.
- . 1994. "Concepts: A Pot Boiler." *Cognition* 50: 95-113.
- Gisiner, R., and R. J. Schusterman. 1992. "Sequence, Syntax, and Semantics: Responses of a Language-Trained Sea Lion (*Zalophus californianus*) to Novel Sign Combinations." *J. Comp. Psych.* 106: 78-91.
- Gleitman, H. 1991. *Psychology*. 3rd ed. New York: W. W. Norton.
- Gleitman, L. R. 1990. "Structural Sources of Verb Learning." *Lang. Acq.* 1: 1-54.
- Golinkoff, R. A. 1986. "I Beg Your Pardon?": The Preverbal Negotiation of Failed Messages." *J. Child Lang.* 13: 455-76.
- Golinkoff, R. M., C. B. Mervis, and K. Hirsh-Pasek. 1994. "Early Object Labels: The Case for Developmental Lexical Principles Framework." *J. Child Lang.* 21: 125-55.
- Goodall, J. 1970. "Tool-Using in Primates and Other Vertebrates." In *Advances in the Study of Behavior*, vol. 3, ed. D. S. Lehrman, R. A. Hinde, and E. Shaw. New York: Academic Press.
- Greenfield, P. M., and E. S. Savage-Rumbaugh. 1993. "Comparing Communicative Competence in Child and Chimps: Pragmatics of Repetition." *J. Child Lang.* 20: 1-26.
- Grice, H. P. 1957. "Meaning." *Phil. Rev.* 66: 377-88.
- . 1968. *Studies in the Way of Words*. Cambridge, Mass.: Harvard University Press.
- Hall, K. R. L., and I. DeVore. 1965. "Baboon Social Behavior." In *Primate Behavior*, ed. I. DeVore. New York: Holt, Rinehart and Winston.
- Hauser, M. D. In press. "Expectations about Object Motion and Destination: Experiments with a Nonhuman Primate." *Developmental Science*.
- Herman, L. M. 1987. "Receptive Competencies of Language-Trained Animals." In *Advances in the Study of Behavior*, vol. 17, ed. J. S. Rosenblatt, C. Beer, C. M. Busnel, and P. J. B. Slater. New York: Academic Press.
- Herman, L. M., and J. A. Gordon. 1974. "Auditory Delayed Matching in the Bottlenose Dolphin." *J. Exp. Anal. Behav.* 21: 19-26.
- Herman, L. M., J. R. Hovancik, J. D. Gory, and G. L. Bradshaw. 1989. "Generalization of Visual Matching by a Bottlenose Dolphin (*Tursiops truncatus*): Evidence for Invariance of Cognitive Performance with

- Visual and Auditory Materials." *J. Exp. Psych.: Anim. Behav. Proc.* 15: 124–36.
- Herman, L. M., S. A. Kuczaj, and M. D. Holder. 1993. "Responses to Anomalous Gestural Sequences by a Language-Trained Dolphin: Evidence for Processing of Semantic Relations and Syntactic Information." *J. Exp. Psych.: Gen.* 122: 184–94.
- Herman, L. M., A. A. Pack, and P. Morel-Samuels. 1993. "Representational and Conceptual Skills of Dolphins." In *Language and Communication: Comparative Perspectives*, ed. H. L. Roitblat, L. M. Herman, and P. E. Nachtigall. Hillsdale, N. J.: Lawrence Erlbaum Assoc.
- Herman, L. M., D. G. Richards, and J. P. Wolz. 1984. "Comprehension of Sentences by Bottlenose Dolphins." *Cognition* 16: 129–219.
- Hermstein, R. J. 1985. "Riddles of Natural Categorization." *Phil. Trans. Roy. Soc. Lond. B.* 308: 129–44.
- Hess, J., M. A. Novak, and D. J. Povinelli. 1993. "'Natural Pointing' in a Rhesus Monkey, But No Evidence of Empathy." *Anim. Behav.* 46: 1023–25.
- Heyes, C. M. In press. "Theory of Mind in Nonhuman Primates." *Behav. Brain Sci.*
- Hirsh-Pasek, K., and R. M. Golinkoff. 1996. *The Origins of Grammar: Evidence from Early Language Comprehension*. Cambridge, Mass.: MIT Bradford Books.
- Humphrey, N. K. 1974. "Species and Individuals in the Perceptual World of Monkeys." *Perception* 3: 105–14.
- Itakura, S., and T. Matsuzawa. 1993. "Acquisition of Personal Pronouns by a Chimpanzee." In *Language and Communication: Comparative Perspectives*, ed. H. L. Roitblat, L. M. Herman, and P. E. Nachtigall. Hillsdale, N. J.: Lawrence Erlbaum Assoc.
- Jackendoff, R. S. 1994. *Patterns in the Mind: Language and Human Nature*. New York: Basic Books.
- Janik, V. M., and P. J. B. Slater. 1996. "Vocal Learning in Mammals." In *Advances in the Study of Behavior*, vol. 26, ed. P. J. B. Slater, J. S. Rosenblatt, C. T. Snowdon, and M. Milinski. San Diego, Calif.: Academic Press.
- Kako, E. In prep. "Elements of Syntax in the Systems of Three Language-Trained Animals."
- Katz, J. J. and J. A. Fodor. 1963. "The Structure of a Semantic Theory." *Language* 39: 170–210.

- Keil, F. C. 1989. *Concepts, Kinds, and Cognitive Development*. Cambridge, Mass.: MIT Bradford Books.
- . 1995. "The Growth of Causal Understandings of Natural Kinds." In *Causal Cognition: A Multi-Disciplinary Approach*, ed. D. Sperber, D. Premack, and A. J. Premack. Oxford: Clarendon Press.
- Limongelli, L., S. T. Boysen, and E. Visalberghi. 1995. "Comprehension of Cause-Effect Relations in a Tool-Using Task by Chimpanzees (*Pan troglodytes*)." *J. Comp. Psych.* 109:18–26.
- Marler, P. 1961. "The Logical Analysis of Communication." *J. Theor. Biol.* 1:295–317.
- . 1990. "Innate Learning Preferences: Signals for Communication." *Develop. Psychobiol.*23: 557–68.
- Matsuzawa, T. 1985. "Use of Numbers by a Chimpanzee." *Nature* 315: 57–59.
- McGrew, W. C. 1994. "Tools Compared: The Material of Culture." In *Chimpanzee Cultures*, ed. R. W. Wrangham, W. C. McGrew, F. B. M. de Waal, and P. G. Heltne. Cambridge, Mass.: Harvard University Press.
- Medin, D. L. 1989. "Concepts and Conceptual Structure." *Am. Psych.* 44: 1469–81.
- Meltzoff, A. N. 1995. "Understanding the Intentions of Others: Re-enactment of Intended Acts by Eighteen-Month-Old Children." *Develop. Psych.* 31: 838–50.
- Mitani, J. 1996. "Comparative Studies of African Ape Vocal Behavior." In *Great Ape Societies*, ed. W. C. McGrew, L. F. Marchant, and T. Nishida. Cambridge: Cambridge University Press.
- Mitani, J., and T. Nishida. 1993. "Contexts and Social Correlates of Long-Distance Calling by Male Chimpanzees." *Anim. Behav.* 45 L 735–46.
- Morford, M., and S. Goldin-Meadow. 1992. "Comprehension and Production of Gesture in Combination with Speech in One-Word Speakers." *J. Child Lang.* 19: 559–80.
- Nagell, K., R. S. Olguin, and M. Tomasello. 1993. "Processes of Social Learning in the Tool Use of Chimpanzees (*Pan troglodytes*) and Human Children (*Homo sapiens*)." *J. Comp. Psych.* 107: 174–86.
- Naigles, L. G., A. Fowler, and A. Helm. 1992. "Developmental Shifts in the Construction of Verb Meanings." *Cog. Develop.* 7: 403–27.
- Newman, J., and D. Symmes. 1982. "Inheritance and Experience in the Acquisition of Primate Acoustic Behavior." In *Primate Communica-*

- tion*, ed. C. T. Snowdon, C. H. Brown, and M. R. Petersen. Cambridge: Cambridge University Press.
- O'Neill, D. K. 1996. "Two-Year-Old Children's Sensitivity to a Parent's Knowledge State When Making Requests." *Child Develop.* 67: 659-77.
- Owren, M. J., J. A. Dieter, R. M. Seyfarth, and D. L. Cheney, 1993. "Vocalizations of Rhesus (*Macaca mulatta*) and Japanese (*M. fuscata*) Macaques Cross-Fostered between Species Show Evidence of Only Limited Modification." *Develop. Psychobiol.* 26: 389-406.
- Pepperberg, I. M. 1981. "Functional Vocalizations by an African Grey Parrot (*Psittacus erithacus*)." *Z. Tierpsychol.* 55: 139-60.
- . 1987. "Acquisition of the Same/Different Concept by an African Grey Parrot (*Psittacus erithacus*), Learning with Respect to Categories of Color, Shape, and Material." *Anim. Learn. Beh.* 15: 423-32.
- . 1992. "Proficient Performance of a Conjunctive, Recursive Task by an African Grey Parrot (*Psittacus erithacus*)." *J. Comp. Psych.* 106: 295-305.
- Perner, J. 1991. *Understanding the Representational Mind*. Cambridge, Mass.: MIT Bradford Books.
- Perrett, D. I., and N. J. Emery. 1994. "Understanding the Intentions of Others from Visual Signals: Neurophysiological Evidence." *Cur. Psych. Cog.* 13: 683-94.
- Perrett, D. I., M. H. Harries, A. J. Mistlin, and J. K. Hietanen. 1990. "Social Signals Analyzed at the Single Cell Level: Someone Is Looking at Me, Something Touched Me, Something Moved." *Int. J. Comp. Psych.* 4: 25-55.
- Perrett, D. I., A. J. Mistlin, and A. J. Chitty. 1987. "Visual Neurones in Response to Faces." *Tr. Neurosci.* 10: 358-64.
- Pinker, S. 1984. *Language Learnability and Language Development*. Cambridge, Mass.: Harvard University Press.
- . 1989. *Learnability and Cognition: The Acquisition of Argument Structure*. Cambridge, Mass.: MIT Press.
- . 1994. *The Language Instinct: How the Mind Creates Language*. New York: William Morrow & Co.
- Povinelli, D. J. 1993. "Reconstructing the Evolution of Mind." *Am. Psych.* 48: 493-509.
- . 1996. "Growing Up Ape." *Mon. Soc. Res. Child Develop.* 61: 174-89.

- Povinelli, D. J., and T. J. Eddy. 1996a. "Factors Influencing Young Chimpanzees' (*Pan troglodytes*) Recognition of Attention." *J. Comp. Psych.* 110: 336-45.
- . 1996b. "What Chimpanzees Know about Seeing." *Mon. Soc. Res. Child Develop.* 61: 1-152.
- Povinelli, D. J., K. E. Nelson, and S. T. Boysen. 1990. "Inferences about Guessing and Knowing by Chimpanzees (*Pan troglodytes*)." *J. Comp. Psych.* 104: 203-10.
- . 1992. "Comprehension of Role Reversal in Chimpanzees: Evidence of Empathy?" *Anim. Behav.* 43: 633-40.
- Povinelli, D. J., K. A. Parks, and M. A. Novak. 1992. "Role Reversal by Rhesus Monkeys But No Evidence of Empathy." *Anim. Behav.* 44: 269-81.
- Premack, D. 1976a. *Intelligence in Ape and Man*. Hillsdale, N.J.: Lawrence Erlbaum Assoc.
- . 1976b. "Mechanisms of Intelligence: Preconditions for Language." In *Origins and Evolution of Language and Speech*, ed. S. R. Harnad, H. D. Steklis, and J. Lancaster. New York: Ann. N.Y. Acad. Sci., 280.
- . 1983. "The Codes of Man and Beast." *Behav. Brain Sci.* 6: 125-67.
- . 1986. *Gavagai! Or the Future History of the Animal Language Controversy*. Cambridge, Mass.: MIT Bradford Books.
- Premack, D., and V. Dasser. 1991. "Perceptual Origins and Conceptual Evidence for Theory of Mind in Apes and Children." In *Natural Theories of Mind: The Evolution, Development, and Simulation of Everyday Mindreading*, ed. A. Whiten. Oxford: Blackwell Scientific.
- Premack, D., and G. Woodruff. 1978. "Does the Chimpanzee Have a Theory of Mind?" *Behav. Brain Sci.* 4: 515-26.
- Quine, W. V. O. 1977. "Natural Kinds." In *Naming, Necessity, and Natural Kinds*, ed. S. P. Schwartz. Ithaca, N.Y.: Cornell University Press.
- Ristau, C., and D. Robbins. 1982. "Language in the Great Apes: A Critical Review." In *Advances in the Study of Behavior*, vol. 12, ed. J. Rosenblatt, R. A. Hinde, C. Beer, and M. C. Busnel. New York: Academic Press.
- Robinson, J. G. 1984. "Syntactic Structures in the Vocalizations of Wedge-Capped Capuchin Monkeys, *Cebus nigrivittatus*." *Behaviour* 90: 46-79.

- Rosch, E. H. 1973. "Natural Categories." *Cog. Psych.* 4: 328–50.
- Savage-Rumbaugh, E. S. 1986. *Ape Language: From Conditioned Response to Symbol*. New York: Columbia University Press.
- Savage-Rumbaugh, E. S., and R. Lewin. 1994. *Kanzi: The Ape at the Brink of the Human Mind*. New York: Wiley.
- Savage-Rumbaugh, E. S., J. Murphy, R. A. Sevcik, and K. E. Brakke. 1993. "Language Comprehension in Ape and Child." *Mon. Soc. Res. Child Develop.* 58: 1–221.
- Savage-Rumbaugh, E. S., S. L. Williams, T. Furuichi, and T. Kano. 1996. "Language Perceived: *Paniscas* Branches Out." In *Great Ape Societies*, ed. W. C. McGrew, L. F. Marchant, and T. Nishida. Cambridge: Cambridge University Press.
- Schusterman, R. J., and R. Gisiner. 1989. "Please Parse the Sentence: Animal Cognition in the Procrustean Bed of Linguistics." *Psych. Rec.* 39: 3–18.
- Schusterman, R. J., R. Gisiner, B. K. Grimm, and E. B. Hanggi. 1993. "Behavior Control by Exclusion and Attempts at Establishing Semanticity in Marine Mammals Using Match-to-Sample Paradigms." In *Language and Communication: Comparative Perspectives*, ed. L. M. Herman and P. E. Nachtigall. Hillsdale, N.J.: Lawrence Erlbaum Assoc.
- Schusterman, R. J., and D. Kastak. 1993. "A California Sea Lion (*Zalophus californianus*) Is Capable of Forming Equivalence Relations." *Psych. Rec.* 43: 823–39.
- Schusterman, R. J., and K. Krieger. 1986. "Artificial Language Comprehension and Size Transposition by a California Sea Lion (*Zalophus californianus*)." *J. Comp. Psych.* 100: 348–55.
- Seidenberg, M. S., and L. A. Pettito. 1979. "Signaling Behavior in Apes: A Critical Review." *Cognition* 7: 177–215.
- Seyfarth, R. M., and D. L. Cheney. 1986. "Vocal Development in Vervet Monkeys." *Anim. Behav.* 34: 1640–58.
- . 1997. "Some General Features of Vocal Development in Non-human Primates." In *Social Influences on Vocal Development*, ed. C. T. Snowdon and M. Hausberger. Cambridge: Cambridge University Press.
- Seyfarth, R. M., D. L. Cheney, and P. Marler. 1980. "Vervet Monkey Alarm Calls: Semantic Communication in a Free-Ranging Primate." *Anim. Behav.* 28: 1070–94.

- Shiple, E. F., C. S. Smith, and L. R. Gleitman. 1969. "A Study in the Acquisition of Language: Free Responses to Commands." *Language* 45: 322-42.
- Silk, J. B., D. L. Cheney, and R. M. Seyfarth. 1996. "The Form and Function of Reconciliation among Baboons, *Papio cynocephalus arsinus*." *Anim. Behav.* 52: 259-68.
- Slobin, D. I., and T. G. Bever. 1982. "Children Use Canonical Sentence Schema: A Cross-Linguistic Study of Word Order and Inflections." *Cognition* 12: 229-65.
- Smith, E. E., and D. L. Medin. 1981. *Categories and Concepts*. Cambridge, Mass.: Harvard University Press.
- Smuts, B. B., and J. M. Watanabe. 1990. "Social Relationships and Ritualized Greetings in Adult Male Baboons (*Papio cynocephalus anubis*)." *Int. J. Primatol.* 11: 147-72.
- Snowdon, C. T. 1990. "Language Capacities of Nonhuman Primates." *Yrbk. Phys. Anthropol.* 33: 215-43.
- Snowdon, C. T., and M. Hausberger (eds.). 1997. *Social Influences on Vocal Development*. Cambridge: Cambridge University Press.
- Spelke, E. S., K. Breinlinger, J. Macomber, and K. Jacobson. 1992. "Origins of Knowledge." *Psych. Rev.* 99: 605-32.
- Stillings, N. A., S. E. Weisler, C. H. Chase, M. H. Feinstein, J. L. Garfield, and E. L. Rissland. 1995. *Cognitive Science: An Introduction*, Cambridge, Mass.: MIT Bradford Books.
- Struhsaker, T. T. 1967. "Auditory Communication among Vervet Monkeys (*Cercopithecus aethiops*)." In *Social Communication among Primates*, ed. S. A. Altmann. Chicago: University of Chicago Press.
- Terrace, H. S., and T. G. Bever. 1976. "What Might Be Learned from Studying Language in the Chimpanzee? The Importance of Symbolizing Oneself." In *Origins and Evolution of Language and Speech*, ed. S. R. Harnad, H. D. Steklis, and J. Lancaster. New York: Ann. N.Y. Acad. Sci. 280
- Terrace, H. S., L. A. Pettito, R. J. Sanders, and T. G. Bever. 1979. "Can an Ape Create a Sentence?" *Science* 206: 891-902.
- Thompson, R. 1995. "Natural and Relational Concepts in Animals." In *Comparative Approaches to Cognitive Science*, ed. H. Roitblat and J. A. Meyer. Cambridge, Mass.: MIT Press.
- Thompson, R. K., and D. L. Oden. 1995. "A Profound Disparity Revisited: Perception and Judgment of Abstract Identity Relations by Chimpanzees, Human Infants, and Monkeys." *Behav. Proc.* 35: 149-61.
- Tomasello, M. 1996a. "Chimpanzee Social Cognition." *Mon. Soc. Res. Child Develop.* 61: 161-73.

- . 1996b. "Do Apes Ape?" In *Social Learning in Animals: The Roots of Culture*, ed. C. M. Heyes and B. G. Galef. New York: Academic Press.
- . In press. "Uniquely Primate, Uniquely Human." *Develop. Sci.*
- Tomasello, M., and J. Call. 1997. *Primate Cognition*. Oxford: Oxford University Press.
- Tomasello, M., M. Davis-Dasilva, L. Camak, and K. Bard. 1987. "Observational Learning of Tool-Use by Young Chimpanzees." *Hum. Evol.* 2: 175–83.
- Tomasello, M., E. S. Savage-Rumbaugh, and A. C. Kruger. 1993. "Imitative Learning of Actions on Objects by Children, Chimpanzees, and Enculturated Chimpanzees." *Child Develop.* 64: 1688–1705.
- Visalberghi, E., and L. Limongelli. 1994. "Lack of Comprehension of Cause-Effect Relations in Tool-Using Capuchin Monkeys (*Cebus apella*)." *J. Comp. Psych.* 108: 15–22.
- Walsh, V., and D. I. Perrett. 1994. "Visual Attention in the Occipitotemporal Processing Stream of the Macaque." Special Issue: The Cognitive Neuropsychology of Attention. *Cog. Neuropsych.* 11: 243–63.
- Wasserman, E. A., and S. L. Astley. 1994. "A Behavioral Analysis of Concepts: Application to Pigeons and Children." *Psychology of Learning and Motivation*, vol. 31, ed. D. L. Medin. New York: Academic Press.
- Wasserman, E. A., C. L. Devolder, and D. J. Coppage. 1992. "Non-Similarity-Based Conceptualization in Pigeons via Secondary or Mediated Generalizations." *Psych. Sci.* 3: 374–78.
- Wellman, H. M. 1990. *The Child's Theory of Mind*. Cambridge, Mass.: MIT Bradford Books.
- Wright, A. A., H. C. Santiago, P. J. Ucuioli, and S. F. Sands. 1983. "Monkeys and Pigeon Acquisition of Same/Different Concept Using Pictorial Stimuli." In *Quantitative Analyses of Behavior: Discriminating Processes*, vol. IV, ed. M. L. Commons, R. J. Herrnstein, and A. R. Wagner. Cambridge, Mass.: Ballinger.
- Zeller, A. C. 1987. "Communication by Sight and Smell." In *Primate Societies*, ed. B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Struhsaker. Chicago: University of Chicago Press.
- Zentall, T. R. 1996. "An Analysis of Imitative Learning in Animals." In *Social Learning in Animals: The Roots of Culture*, ed. C. M. Heyes and B. G. Galef. New York: Academic Press.
- Zuberbuhler, K., R. Noe, and R. M. Seyfarth. 1997. "Diana Monkey Long-Distance Calls: Messages for Conspecifics and Predators." *Anim. Behav.* 53: 589–604.