CHAPTER 10

Social Cognition in Primates

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I. INTRODUCTION

A. History and Definition

Investigations of complex social behavior in nonhuman primates received new impetus and began to be described as studies of "social cognition" in the late 1970s following publication of the "social function of intellect" or "social intelligence" hypothesis (Humphrey, 1976; see also Chance & Mead, 1953; Jolly, 1966), and the suggestion that chimpanzees may have a "theory of mind" (Premack & Woodruff, 1978). The former proposed that the social, rather than the physical, environment was the principle source of selection pressure for the evolution of primate intelligence, and the latter raised the possibility that individual chimpanzees and other nonhuman primates (henceforward simply "primates") may attribute mental states, such as beliefs and desires, to themselves and to others.

Broad definitions of social cognition portray all recent studies of primate social behavior as investigations of social cognition (Cheney & Seyfarth, 1990b; 1992; de Waal, 1991; Kummer, Dasser, & Hoyningen-Huene, 1990; Quiatt & Reynolds, 1993), but a substantial proportion of these studies are of relatively little interest to psychologists. They either document patterns of spontaneous social behavior without giving any indication of the psycho-

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logical processes responsible, or are thought to show that perceptual and associative mechanisms well known to be responsible for processing information from the physical or asocial environment are also activated by social stimuli. Studies of this kind will be neglected in the present review in favor of research that provides, or is widely thought to provide, evidence of *distinctively* social cognition, that is, of cognitive processes that operate only or typically on information derived from, or relevant to, other animals. One of the virtues of this restriction is that it means that we do not have to take any stance on the question of whether the processes of associative learning are either "cognitive" or "noncognitive" (Dickinson, 1983; Premack, 1983). It is sufficient to note that, since these processes commonly operate on asocial input, associative learning is not a variety of distinctively social cognition.

B. Overview

The social function of intellect hypothesis is widely cited but its influence on research in social cognition has been indirect. The hypothesis clearly predicts that "there should be a positive correlation across species between 'social complexity' and 'individual intelligence'" (Humphrey, 1976, p. 26), and yet this prediction has not been tested in studies of social cognition (Macphail, 1991). Instead of attempting to correlate these variables across a broad range of primate and nonprimate species, researchers have focused on primates that spend a large proportion of their time engaged in complex social interactions, and have examined, not their general intellectual ability, but their capacity to process social information. Thus, the social function of intellect hypothesis has functioned less as a hypothesis than as a general guide to where in the animal kingdom social cognition is most likely to be found.

The majority of studies reviewed here concern primates but experiments on other animals are mentioned. These are rarely regarded as investigations of social cognition but in many cases the evidence that they provide is as strong as that of primate studies. Consequently, depending on one's assumptions about the evolution of intelligence and the appropriate application of Ockham's razor, research on rodents and birds either indicates that social cognition is relatively widespread among vertebrates, or acts as a reminder that more general processes may be responsible for behavior suggestive of social cognition.

In contrast with the indirect and yet conspicuous influence of the social function of intellect hypothesis, the effect of Premack and Woodruff's (1978) theory of mind hypothesis has been immense but not always obvious. All studies of social cognition in primates have been either explicitly designed to investigate the possibility that they attribute mental states or derive

psychological interest from their bearing on this issue. However, the role played by Premack and Woodruff (1978) in stimulating this research is not always apparent because, in addition to "theory of mind," the focus of study is known as "Machiavellian intelligence" (Byrne & Whiten, 1988; Whiten & Byrne, 1988), "metarepresentation" (Whiten & Byrne, 1991), "politics" (de Waal, 1982), "metacognition" (Povinelli, in press), "mind reading" (Krebs & Dawkins, 1984; Whiten, 1991), "perspective-taking" (Povinelli, Nelson & Boysen, 1990), and "mental state attribution" (Cheney & Seyfarth, 1990a; 1990b, 1992). The latter term is used here because it is the most general and soberly descriptive. To say that an animal has a "theory of mind" may imply that the animal infers the presence of particular mental states in others using lawlike generalizations about mental states and behavior (Goldman, 1993). However, this was not the sense in which Premack and Woodruff (1978) used the term, and subsequent research has not addressed the question of how, if at all, animals derive mental state attributions.

Studies of six types of behavior will be reviewed (Section II): imitation, mirror-guided body inspection (or self-recognition), discrimination of social relationships, deception, role taking (or empathy), and perspective taking. The current consensus is that these studies provide convergent evidence that chimpanzees and possibly other apes, but not monkeys, engage in mental state attribution (Byrne, 1993; Cheney & Seyfarth, 1990b; 1992; de Waal, 1991; Gallup, 1982; Jolly, 1991; Povinelli, 1993, in press; Whiten & Byrne, 1991). Research on symbolic communication and teaching has also contributed to this consensus (see Chapter 12 by Savage-Rumbaugh this volume, and Premack, 1991, respectively, for reviews). Within each of the six sections, two questions are addressed: (1) Which primates, if any, exhibit the behavior? and (2) To what extent is the behavior indicative of mental state attribution? Viewed as measures of mental state attribution, the six types of behavior are considered in roughly ascending order of current internal and construct validity (Cook & Campbell, 1979). For example, imitation is considered first because relatively little of the available evidence of behavioral copying is compelling, and behavioral copying only weakly implies a capacity to attribute mental states. Perspective taking is discussed last because there is a procedure that has the potential to detect this behavior fairly reliably, and, under certain conditions, perspective taking would directly imply a capacity for mental state attribution.

II. REVIEW OF EMPIRICAL STUDIES

A. Imitation

Continuity between earlier research in comparative psychology and investigations of social cognition is most apparent in the study of imitation. Com-

parative psychologists have long regarded motor imitation (the spontaneous reproduction of acts yielding disparate sensory input when observed and executed) as a sign of higher intelligence, and sought evidence that it occurs among nonhuman animals (Thorndike, 1898). However, after nearly 100 years of research, there is still no unequivocal evidence of motor imitation in any primate species (Byrne, 1993; Crawford, 1939; Galef, 1988; Tomasello, Davis-Dasilva, Camak, & Bard, 1987; Visalberghi & Fragaszy, 1992).

Under uncontrolled and semicontrolled conditions the occurrence of imitation in monkeys (Beck, 1976; Hauser, 1988; Kawai, 1965; Nishida, 1986; Westergaard, 1988) and chimpanzees (de Waal, 1982; Goodall, 1986; Mignault, 1985; Sumita, Kitahara-Frisch, & Norikoshi, 1985; Terrace, Petitto, Sanders, & Bever, 1979) has been inferred from the performance of a complex, novel, previously observed act by a single animal or a succession of animals within a group. Even if one disregards the potential lack of reliability of these observational or anecdotal data, they are not compelling. In all cases, the observed behavior could have been acquired by a means other than imitation (e.g., trial-and-error learning), and in many cases there is evidence that it was so acquired (Adams-Curtis, 1987; Fragaszy & Visalberghi, 1989; 1990; Galef, 1992; Visalberghi & Trinca, 1989). For example, the habit of potato washing was supposed to have been transmitted through the population of Japanese macaques on Koshima Island through imitation (Kawai, 1965; Nishida, 1986). However, given the order in which members of the troop were observed engaging in this behavior (first a juvenile, Imo, then her playmates, then their mothers), it is equally likely that, rather than copying the actions of potato washers, naïve animals followed or chased them into water while holding a potato. Once in that position, the pursuing animal would only have to drop and then retrieve its potato, now sand free and with a salty taste, to acquire the behavior. Furthermore, the hypothesis that potato washing spread through following rather than imitation is consistent both with the slow rate of transmission on Koshima Island (Galef, 1992), and evidence that isolated monkeys readily learn to wash sandy food when they find it close to water (Visalberghi & Fragaszy, 1992).

A further example concerns a chimpanzee, Nim, that was trained to use American Sign Language (ASL) (Terrace et al., 1979). Analysis of Nim's ASL utterances suggested that, rather than using signs creatively to communicate, he frequently copied sequences of signs that had recently been used by a human trainer. However, there is reason to doubt that this copying behavior is indicative of a capacity beyond that of associative learning. Nim was trained in ASL using a mixture of informal methods including "molding" (physical guidance of the animal's hands by a trainer), and praise for correct or partially correct production of signs. Consequently, his ability to copy signs could have been due, not to spontaneous matching of observed

and executed behavior, but to instrumental training in which the trainer's signs acted as discriminative stimuli indicating that matching signs would be rewarded. In this case, the trainer, but not the chimpanzee, would be sensitive to the topographical similarity between the trainer's and the chimpanzee's behavior.

Remarkably few experiments have been conducted on imitation in primates (or in other species), and their results may indicate merely that observation of action can influence the degree to which the observer subsequently attends to certain physical components of a problem situation. This sort of interpretation, in terms of "stimulus enhancement" (Galef, 1988; Heyes, in press; Spence, 1937) is certainly the most natural for early experiments in which monkeys and chimpanzees were presented with a succession of pairs of objects and learned to touch or displace the member of each pair to which they had observed a conspecific making a rewarded response (Crawford, 1939; Warden & Jackson, 1935). Using a similar procedure, Darby and Riopelle (1959) showed that rhesus monkeys can learn to displace the same object as a conspecific when the demonstrator's response revealed food, and to select an alternative object when it did not reveal food. This suggests that, in addition to showing stimulus enhancement, monkeys can learn through observation about relationships among stimuli, but it does not indicate a capacity to imitate, to learn about responses or response-reinforcer relationships by observation.

A concerted attempt to distinguish imitation from stimulus enhancement and other kinds of social learning has been made in only three experiments with primates, all involving chimpanzees (Hayes & Hayes, 1952; Tomasello et al., 1987; Tomasello, Savage-Rumbaugh, & Kruger, in press). In the first (Tomasello et al., 1987), experimental animals that had observed a conspecific demonstrator using three distinctive techniques to rake in food with a T bar were more successful in using the T bar to obtain food than were control animals that had not observed the instrument in use prior to testing. However, the experimental group contacted the T bar more than the controls at pretest, prior to demonstrator observation, and therefore their superior performance may not have reflected social influence of any kind. Further, if demonstrator observation did play a role, it may have been via stimulus enhancement. Unlike the control animals, those in the experimental group saw the demonstrator contacting the T bar, and this experience may have led them to spend more of the test time engaged in trial-and-error learning with the instrument. As Tomasello et al. (1987) pointed out, there was certainly no evidence of imitation in the form of a tendency on the part of experimental animals to apply the same movements to the T bar as had their demonstrator.

In the second experiment (Tomasello et al., in press), "enculturated" chimpanzees (i.e., animals with an extensive training history), relatively

naïve chimpanzees, and young children observed the experimenter manipulating 16 objects in various ways and, after observing each action, were given access to the same object either immediately or after a 48-hour delay. When the test was given immediately, and the results for all objects were combined, the "enculturated" chimpanzees were comparable to the children in their tendency to act on the same part of the object, and with the same effect, as the demonstrator. However, for many objects, resemblance between the demonstrator and the observer could have been coincidental or due to stimulus enhancement rather than imitation. For example, when presented with a paint brush, the chimpanzees may have squeezed it with one hand, not because they had observed the trainer executing this or any other action in relation to the brush, but simply in an effort to grasp a novel object. Similarly, observation of the trainer turning a spigot to release rope may have increased the probability that the chimpanzees would touch the spigot when given the opportunity to do so. Once in contact with the spigot, they could quickly discover that it can be turned, and that this operation releases rope. The finding that "enculturated" chimpanzees were actually superior to children under delayed test conditions casts further doubt on the view that the chimpanzees were imitating. There can be little doubt that the children were imitating, and this result suggests that different processes were responsible for the performance of children and chimpanzees.

The significance of the third experiment on imitation in chimpanzees (Hayes & Hayes, 1952) is difficult to assess because neither the procedure nor the results were reported in detail. Hayes and Hayes (1952) gave Viki, a "home-raised" chimpanzee, a series of 70 "imitation set" tasks. Each task consisted of the experimenter saying, "Do this," and then performing an action such as patting his head, clapping his hands, or operating a toy. If Viki performed a similar action within a few seconds, she was rewarded with food; otherwise the experimenter repeated the action or helped Viki to make the response by, for example, manipulating her hands. Viki was said to have required help in executing each of the first 11 actions, but to have begun with the 12th item to imitate immediately test actions that were already part of her repertoire. Further, it was claimed that, beginning with the 20th task, Viki copied at least 10 completely novel actions.

Taken at face value, the results of this study suggest that Viki did not show spontaneous imitation, but that she learned to imitate through a procedure in which imitative responding was shaped both manually and by selective reinforcement, and that she was able to generalize on the basis of this training. While associative processes may mediate learning to imitate through shaping (see the discussion above of language-trained apes), learning of this kind would be unlikely to generalize to novel actions. Thus, if Viki imitated novel actions, even after shaping, there would be reason to

believe that she was capable of some kind of distinctively social cognition. However, this conclusion is not secure because the report on Viki's behavior provided no indication of either the method used to measure the similarity between the experimenter's and the chimpanzee's behavior, or of the degree of similarity observed.

The paucity of evidence of imitation in primates indicates neither that they are unable to imitate nor that such evidence is difficult to obtain for nonhuman animals. Relatively unequivocal evidence of imitation in budgerigars (Galef, Manzig, & Field, 1986) and rats (Heyes & Dawson, 1990; Heyes, Dawson, & Nokes, 1992) has been found by comparing the behavior of subjects that have observed a conspecific acting on a single object in one of two distinctive ways. In addition to providing a methodological lead for primate research, these studies of species that are relatively distantly related to humans are a reminder that, while an imitator may seem to represent the imitated animal's mental state, its point of view, or its beliefs and desires (as suggested by Gallup, 1982; Povinelli, in press; Whiten & Byrne, 1991; Whiten & Ham, 1992), there is no compelling reason to believe that it does so. What is apparently essential for imitation is that the imitating animal represent what the demonstrator did, not what it thought (Heyes, 1993b).

A number of researchers treat imitation as an indicator of mental state attribution, while acknowledging that other processes could also lead to the reproduction of novel, complex acts (Byrne, 1993; Tomasello, Kruger, & Ratner, 1993). However, until mental state attribution can be distinguished empirically from these other processes, imitation must be regarded as a rather poor indicator of mental state attribution in general, and as one that has yielded no evidence of that ability in primates.

B. Mirror-Guided Body Inspection

A series of experiments using a common procedure apparently indicate that chimpanzees and orangutans, but not other primates, are capable of "self-recognition" or mirror-guided body inspection, that is, will use a mirror as a source of information about their own bodies (Cheney & Seyfarth, 1990b; Gallup, 1982; Jolly, 1991; Povinelli, 1987; Whiten & Byrne, 1991). In the standard procedure (Gallup, 1970), an animal with some experience of mirrors is anesthetized and marked on its head with a red, odorless, nonirritant dye; several hours later, the frequency with which the animal touches the marks on its head is measured first in the absence of a mirror and then with a mirror present. Under these circumstances, chimpanzees and orangutans typically touch their head marks more when the mirror is present than when it is absent, while monkeys of various species and gorillas touch their marks with the same low frequency in both conditions (Calhoun &

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(Pearce, 1989). Thus, the results of mark tests leave open the possibilities that all, none, or some primates are capable of mirror-guided body inspection.

Described as "self-recognition," mirror-guided body inspection has been said to imply the possession of a "self-concept" and the potential to imagine oneself as one is viewed by others, that is, to attribute mental states (Gallup, 1982; Povinelli, 1987; Whiten & Byrne, 1991), but this is also doubtful. To use a mirror as a source of information about its body, an animal must be able to distinguish, across a fairly broad range, sensory inputs resulting from the physical state and operations of its own body, from sensory inputs

originating elsewhere. If the animal could not do this, if it lacked what might be described loosely as a "body concept," then presumably it could not learn that, when it is standing in front of a mirror, inputs from the mirror correlate with inputs from its body. However, since this "body concept" is equally necessary for mirror-guided body inspection and for collision-free locomotion, it is not clear that the former implies mental state attribution any more than does the latter (Heyes, 1994).

A demonstration that pigeons can be trained to use a mirror to detect paper dots attached to their feathers (Epstein, Lanza, & Skinner, 1981; Gallup, 1983; Premack, 1983) makes it easier to appreciate that mirror-guided body inspection may not imply mental state attribution. However, more direct evidence of a dissociation between the two is provided by studies of autistic children who, although apparently incapable of ascribing beliefs to others, begin to engage in mirror-guided body inspection at the same age as normal children (Ungerer, 1989).

C. Social Relationships

There is a substantial body of evidence suggesting that the social behavior of primates is affected not only by concurrent stimulation and the outcomes of previous, active engagements between the present interactants and third parties. In addition, the behavior of animal A in relation to animal B may be affected by A's prior observations of B in relation to one or a number of other conspecifics, C, D, and so on. Evidence of this kind (Cheney & Seyfarth, 1990b; Hinde, 1983; Smuts, Cheney, Seyfarth, Wrangham, & Struhsaker, 1987) has been derived from observational and experimental studies of chimpanzees (de Waal, 1982; de Waal & Van Roosmalen, 1979), baboons (Bachmann & Kummer, 1980; Kummer, 1968; Smuts, 1985), and various macaques (Anderson & Mason, 1978; Cheney & Seyfarth, 1980, 1986; Dasser, 1988; Datta, 1983; Judge, 1982, 1983; Stammbach, 1988). For example, adult male chimpanzees are more likely to disrupt (through interposition, aggression, or a threat display) social interactions between pairs of high-ranking conspecifics than between pairs of mixed or low-rank conspecifics (de Waal, 1982). Similarly, adult male baboons are less likely to challenge the resident male of a one-male, multifemale unit if the females groom the resident male with a high frequency (Bachmann & Kummer, 1980), and both baboons and macaques are more likely to respond to an aggressor by attacking a bystander when the bystander is a relative of the aggressor, or when the bystander and aggressor commonly engage in affiliative social interactions (Judge, 1982; Smuts, 1985).

This literature indicates that the social behavior of animals from a broad range of primate species is sensitive to what human observers naturally describe as "social relationships" among conspecifics. It has been said, in

addition, to show that primates have knowledge of social relationships (Cheney, Seyfarth, & Smuts, 1986; Cheney & Seyfarth, 1990b; de Waal, 1991; Kummer et al., 1990) and this seems entirely appropriate when the term knowledge is used in a general sense, and social relationships are understood to be observable properties. If, on the other hand, knowledge of social relationships is taken to consist of information about conditions (such as mental states) that are not directly observable, acquired by a means other than associative learning and/or represented in an "abstract" code (Cheney & Seyfarth, 1990b; 1992; Dasser, 1988; de Waal, 1991), then the evidence to date does not support the inference that primates know about social relationships.

Few researchers would contest this conclusion, and therefore consideration of two studies is sufficient to illustrate the plausibility of simple associative accounts of sensitivity to social relationships. In the first (Cheney & Seyfarth, 1980), free-ranging vervet monkeys were played the scream of an absent juvenile from a concealed loudspeaker. The adult female monkeys in the group typically responded to the sound of the juvenile's cry by looking at the juvenile's mother before the mother had responded to the cry herself. In so doing they displayed sensitivity to, or knowledge of, the mother–offspring relationship. But this could clearly have resulted from earlier exposure to a contingency between the cries of a particular juvenile and a vigorous behavioral response from a particular adult female (Cheney et al., 1986).

In the second study (Stammbach, 1988), one subordinate member of each of a number of groups of long-tailed monkeys was trained to obtain preferred food for the group by manipulating three levers. The other monkeys did not acquire the skill themselves, but those that received the most food as a result of the trained animals' activities began to follow them to the lever apparatus, and spent an increasing amount of time sitting beside and grooming the trained animals, even when the apparatus was not in operation. The untrained monkeys may have behaved in this way because they appreciated that the trained individuals had superior knowledge of the workings of the lever apparatus, and wanted to develop friendly relations with them in the hope of gaining more food in the future (Kummer et al., 1990; Stammbach, 1988). However, the results of an experiment with rats show that, rather than attributing superior knowledge, each untrained monkey may have learned an association between the trained animal in their group and receipt of preferred food. In this study (Timberlake & Grant, 1975), rats acquired affiliative social responding to a conspecific that was fastened to a trolley and wheeled into an operant chamber as a signal for the delivery of food.

Experiments by Dasser (1988) used a method that may be useful in future research on primates' knowledge of social relationships. In one of these, a

female Java monkey was first rewarded for responding to a photographic slide of a particular mother–daughter duo in her social group, and not rewarded for responding to a simultaneously presented slide of one of five other duos of familiar conspecifics. In each of 14 subsequent transfer trials, she was shown a pair of slides of group members that had not been represented in prior training, and on every trial she chose the slide of a mother–daughter duo rather than the slide of another duo of similar relative size and gender. There are a number of obstacles to the conclusion that the subject in this experiment used an "abstract category analogous to our concept of mother–child affiliation" (Dasser, 1988; p. 229). For example, without detailed analysis of the stimulus materials, it is difficult to exclude the possibility that the monkey was using a relatively simple cue, such as relative posture, to make the discrimination (Chater & Heyes, in press; Premack, 1983). However, with appropriate control over slide content, use of a discrimination learning technique of this kind (see also Demaria & Thierry, 1988) may indicate more clearly what primates know about social relationships, and, consequently, how this information is acquired. As things stand, there is no reason to suggest that primates learn about social relationships in a different way from that by which they learn about other relationships in their environment—through processes of association.

D. Role Taking

In the experiments that gave rise to the suggestion that primates may have a theory of mind (Premack & Woodruff, 1978), a "language-trained" chimpanzee, Sarah, was shown videotapes depicting human actors confronting problems of various kinds, for example, trying to reach inaccessible food, to escape from a locked cage, and to cope with malfunctioning equipment. The final image of each videotape sequence was put on hold, and Sarah was offered a choice of two photographs to place beside the video monitor. Both of these represented the actor in the problem situation, but only one of them showed the actor taking a course of action that would solve the problem. Sarah consistently chose the photographs representing problem solutions, and this was interpreted as evidence that she attributed mental states to the actor (Premack & Woodruff, 1978; see Premack, 1983, 1988, for reservations about this conclusion). It was argued that if Sarah did not ascribe beliefs and desires to the actor, then she would see the video as an undifferentiated sequence of events, rather than a problem. In this case, she would be expected either to respond at random, or to choose from each pair of photographs the one that was more attractive to her, or that bore a greater physical resemblance to the videotape.

Close examination of the videotape experiments (Premack & Premack, 1982; Premack & Woodruff, 1978) suggests that Sarah could, for any given

problem, have responded on the basis of familiarity, physical matching, and/or formerly learned associations. For example, when the actor was trying to reach food that was horizontally out of reach, matching could have been responsible for Sarah's success because a horizontal stick was prominent in both the final frame of the videotape and in the photograph depicting a solution. Similarly, when the actor was shivering and looking wryly at a broken heater, Sarah may have selected the photograph of a burning roll of paper, rather than an unlit or spent wick, because she associated the heater with the red-orange color of fire. However, taken together, the results of the videotape experiments are not subject to a single, simple "killjoy" interpretation (Dennett, 1983), and in this respect they are apparently unique within the literature on social cognition in primates.

It is unfortunate that the results of other experiments on role taking (Povinelli, Nelson, & Boysen, 1992; Povinelli, Parks, & Novak, 1992) do not facilitate interpretation of Premack and Woodruff's findings. In one of these (Povinelli, Nelson, & Boysen, 1992), four chimpanzees were initially trained either to choose from an array of containers the one to which an experimenter was pointing (cue-detection task), or to observe food being placed in one of the containers and then to point at the baited receptacle (cue-provision task). Once criterion performance had been achieved on the initial problem, each chimpanzee was confronted with the alternative task, and three of the four animals swiftly attained a high level of accuracy during this second phase of the experiment.

This result was interpreted as evidence of role taking or "cognitive empathy" (Povinelli, Nelson, & Boysen, 1992), but it is subject to another interpretation. The chimpanzees may have quickly achieved a high level of accuracy on the second task, not because the first had allowed them to imagine the situation from another's perspective, but because they had learned most of what they needed to know to solve the second problem during pretraining and outside the experimental situation. The chimpanzees had learned to pull the levers to obtain food during pretraining, and they commonly encountered and exhibited pointing behavior in their day-to-day laboratory lives. When rhesus monkeys, which lacked prior experience of pointing, were switched from cue-provision to cue-detection tasks, or vice versa, they did not immediately succeed on their second problem (Mason & Hollis, 1962; Povinelli, Parks, & Novak, 1992).

If the results of the chimpanzee experiment (Povinelli, Nelson, & Boysen, 1992) had shown that each problem (cue detection and cue provision) was learned faster when it was presented second than when it was presented first, there would be reason to believe that some feature of the first task had facilitated performance in the second. However, even in this case, further experiments, varying the requirements of the first task, would be necessary to find out which feature was enhancing second-task performance, and it is

not clear which manipulations, if any, could provide unambiguous evidence that the opportunity for mental state attribution was responsible (Heyes, 1993).

In sum, Sarah, a chimpanzee with an extensive training history, is the only animal that has provided evidence suggestive of mental state attribution in a study of role taking.

E. Deception

When applied to animal behavior, the term deception is often used in a functional sense (Krebs & Dawkins, 1984) to refer to the provision by one animal, through production or suppression of behavior, of a cue that is likely to lead another to make an incorrect or maladaptive response. A mass of observational and anecdotal data leave little doubt that, thus defined, deception occurs in a broad variety of primate and nonprimate species (for recent reviews, see Cheney & Seyfarth, 1991; Krebs & Dawkins, 1984; Mitchell & Thompson, 1986; Whiten & Byrne, 1988). For example, some male scorpion flies adopt the posture and behavior of females, thereby eliciting mating gifts from other males (Thornhill, 1979); chimpanzees occasionally preface aggressive behavior with appeasement gestures (de Waal, in Cheney & Seyfarth, 1991); and various species of birds, vervet monkeys, and chimpanzees sometimes give predator alarm calls in the absence of predators (Cheney & Seyfarth, 1990b; de Waal, 1986; Moller, 1988; Munn, 1986).

While there can be no doubt about the widespread occurrence of functionally deceptive behavior, the research necessary to find out whether it involves mental state attribution has barely begun. There have been many carefully conducted studies of deceptive behavior in nonprimate species but, since this behavior tends to be inflexible and domain specific, they are not thought to indicate intentional deception. Examples include the mating behavior of male scorpion flies (see above), and the practice among male pied flycatchers of tricking females into polygamy by maintaining two, geographically distant territories (Alatalo, Carlson, Lundberg, & Ulstrand, 1981; Alatalo, Lundberg, & Stahlbrandt, 1984). In contrast, it is commonly claimed that primates act with the intention of producing or sustaining a state of ignorance or false belief in another animal, and yet the evidence to date is almost exclusively anecdotal (Cheney & Seyfarth, 1991; Whiten & Byrne, 1988), and the behavior described in each anecdote is subject to at least one alternative interpretation.

In a number of anecdotes, intentional deception is inferred from the fact that one primate has approached another in a friendly way, and then launched an attack. For example, "If Puist [a chimpanzee] is unable to get a hold of her opponent during a fight, we may see her walk slowly up to her

and then attack unexpectedly. She may also invite her opponent to reconciliation in the customary way. She holds out her hand and when the other hesitantly puts her hand in Puist's, she suddenly grabs hold of her. This has been seen repeatedly and creates the impression of a deliberate attempt to feign good intentions in order to square accounts" (de Waal, 1982). In cases such as this one, it is undoubtedly natural to assume that the protagonist deliberately deceived its opponent but, as Mackintosh (in press) has pointed out, the behavior is just what one would expect from studies in which animals such as the laboratory rat are confronted with an object that has been associated with both positive and negative consequences. Under these circumstances, the rat will approach the object with increasing hesitation, and dart away again if it gets too close. This suggests that attraction generalizes more widely that aversion, and therefore that Puist may have felt genuinely friendly as she approached the other chimpanzee, a feeling that switched to aggression when she got too close.

Other informal reports of deceptive behavior invite several alternative interpretations: that the behavior occurred: (1) by chance; (2) as a result of associative learning; or (3) as a product of inferences about observable features of the situation rather than mental states (Heyes, 1993; Kummer et al., 1990; Premack, 1988). For example, "One of the female baboons at Gilgil grew particularly fond of meat, although the males do most of the hunting. A male, one who does not willingly share, caught an antelope. The female edged up to him and groomed him until he lolled back under her attentions. She then snatched the antelope carcass and ran" (Jolly, 1985).

The female baboon may have intended to deceive the male about her intentions, but it may also have been no more than a coincidence that she began grooming the male when he was holding the carcass, and made a grab for the carcass when he was lolling back. This could be tested by measuring the frequency with which female baboons groom males who are not in possession of a valuable resource, and thereby assessing the probability that the female in the narrative groomed the male because he was holding a carcass. If the probability turned out to be low, this procedure would allow the "chance" explanation to be discounted.

More intractable problems emerge when one considers a second possibility, that the female's behavior was acquired through associative learning. For example, she may have snatched the carcass when the male was lolling back because in the past similar acts had proved rewarding when executed in relation to supine individuals. That is, the female could have snatched food from conspecifics on many previous occasions, initially without regard to their posture, but if she got away with it when the victim was supine, and not when the victim was upright, she might have acquired an association between snatching food and reward that was activated by the sight of a supine animal. It is not clear how, if at all, observational data could be used

to distinguish an associative account of deceptive behavior from an account in terms of mental state attribution. Students of animal behavior used to assume that associative learning occurs gradually, while the effects of inferential learning, or reasoning, suddenly become apparent in behavior (e.g., Kohler, 1925). If this were true, and if observational data could indicate reliably whether learning was gradual or abrupt, then they may be sufficient to distinguish the two accounts. But it would appear not to be true. The many reports of one-trial food aversion learning in rats show that associative learning can be abrupt (e.g., Kaye, Gambini, & Mackintosh, 1988), and evidence that animals acquire beliefs about the relationship between lever pressing and food in the course of instrumental training (Dickinson & Dawson, 1989; Heyes & Dickinson, 1990) imply that the consequences of inferential learning may only gradually become apparent in behavior.

Even if observational studies of deceptive behavior could show that it was acquired through an inferential process, there would remain the possibility that the behavior was based on reasoning about observable features of the situation, rather than mental states. Thus, the female baboon may have inferred from her experience of conspecific behavior that it is relatively safe to snatch food when the other animal is lying back, but she need not have regarded posture as an indicator of mental state. It has been suggested that, if not single anecdotes, collections of such reports, each relating to the behavior of a different individual, could provide clear evidence that reasoning about mental states, rather than observable features of a situation, is responsible for deceptive behavior (Whiten & Byrne, 1988). However, this does not appear to be the case when one considers the hypothetical example of three animals observed, on separate occasions, snatching food that was previously available to a conspecific. The first grooms the conspecific and snatches when it is supine, the second presents and grabs when the male is sexually excited, and the third throws a missile and makes his move when the conspecific is giving chase. We humans might feel inclined to attribute the state of "intending to deceive with intimate behaviour" to all three animals (Whiten & Byrne, 1988), but the potential to attract the same mental state attribution from us might be the sum of what the three have in common regarding mental state attribution. Even if we could be sure that none of them had simply been lucky, and that all of them had acquired the behavior through some inferential process, the possibility would remain that they had learned to snatch from supine, sexually excited, and departing individuals, respectively.

The results of the only experimental investigation of intentional deception in primates (Woodruff & Premack, 1979) are also equivocal. At the beginning of each trial in this study, a chimpanzee was allowed to observe food being placed in one of several inaccessible containers, and then a human trainer, dressed in green ("cooperative" trainer) or white ("competi-

tive" trainer), entered the room and searched one of the containers. The trainer had been instructed to choose the container that the chimpanzee appeared to indicate through pointing, looking, or body orientation. When the cooperative trainer found food, he gave it to the chimpanzee, but the chimpanzee was rewarded on competitive trainer trials only if the trainer chose the incorrect container. After 120 trials, each of the four chimpanzees tested showed a significant tendency to indicate the baited container in the presence of the cooperative trainer, and an empty container in the presence of the competitive trainer. Thus, the chimpanzees' behavior toward the competitive trainer was deceptive, in the functional sense, but the process underlying this behavior is not clear. The animals may have intended to induce in the competitive trainer a false belief about the location of food, or they may have learned, through association or otherwise, that indicating the baited container in the presence of a trainer wearing green led to nonreward (Dennett, 1983; Heyes, 1993).

Recent studies of children underline the difficulty of establishing, using nonverbal tests, that functionally deceptive behavior involves mental state attribution. Chandler, Fritz, and Hala (1989) engaged two- and three-year-old children in a board game in which "treasure" could be hidden in one of several cups with the aid of a puppet that left inky tracks. When they had been familiarized with the situation, the children were encouraged to hide the treasure such that one of the experimenters, who had temporarily left the room, would not find it. Children as young as two and a half years of age used a sponge to wipe away telltale tracks, and/or added false trails to empty cups, and this was taken to indicate that children of this age are capable of attributing ignorance or a false belief to another person, and of acting to encourage such a belief. However subsequent studies (Sodian, Taylor, Harris, & Perner, 1991) showed that children under four years of age who erase tracks and leave misleading trails do not answer questions in a manner that is consistent with this interpretation. When asked where the dupe would believe the treasure to be hidden, they indicated the cup that actually contained the treasure, not the one to which a false trail had been laid. Sodian et al. (1991) concluded that children become capable of intentional, rather than functional, deception at around the age of four years.

F. Perspective Taking

It is a fundamental tenet of the human theory of mind that, under many circumstances, "seeing is believing." When an individual has had visual access to a state of affairs, X, they are likely to know about X, but when they have not, they are likely to be ignorant with respect to X. Consequently, if a nonhuman animal were spontaneously to behave in a different way toward individuals when they have and have not had visual access to an

event, and if this behavior were akin to what a human would do when they took another to be either knowledgeable or ignorant with respect to that event, there would be a strong *prima facie* case for mental state attribution by the animal.

Several experiments on "perspective taking" in primates (Cheney & Seyfarth, 1990a; Povinelli et al., 1990; Povinelli, Parks, & Novak, 1991; Premack, 1988; see also Menzel, 1971) have been based on this kind of reasoning. Like studies of deception, they seek evidence that primates attribute beliefs by examining whether the social behavior of protagonists is attuned to the degree to which their interactants have had perceptual access to critical events. However, in research on perspective taking, the focal social behavior is not functionally deceptive, and, to date, vision is the only perceptual modality that has been given explicit consideration.

Two studies of perspective taking in monkeys (Cheney & Seyfarth, 1990a; Povinelli et al., 1991), and several involving chimpanzees (Premack, 1988), reported failure to find evidence that the animals behaved in a different way toward interactants that had, and had not, had visual access to critical events. In the remaining study (Povinelli et al., 1990), chimpanzees were tested in a two-stage procedure. At the beginning of each trial in the first, discrimination training, stage, a chimpanzee was in a room with two trainers. One trainer, designated the "Guesser," left the room, and the other, the "Knower," baited one of four containers. The containers were screened such that the chimpanzee could see who had done the baiting, but not where the food had been placed. After baiting, the Guesser returned to the room, the screen was removed, and each trainer pointed directly at a container. The Knower pointed at the baited container, and the Guesser at one of the other three, chosen at random. The chimpanzee was allowed to search one container, and to keep the food if it was found.

Two of the four animals tested in this way quickly acquired a tendency to select the container indicated by the Knower more often than that indicated by the Guesser, and the second stage of the procedure was designed to find out whether this discrimination was based on the trainers' visual access to the baiting operation. In each trial of this transfer stage, baiting was done by a third trainer in the presence of both the Knower and the Guesser, but during baiting the Guesser had a paper bag over his head. For each chimpanzee, mean choice accuracy in the final 50 trials of Stage 1 was comparable with that in the 30 trials of Stage 2, and this transfer performance was taken to indicate that the chimpanzees were "modelling the visual perspectives of others" (Povinelli et al., 1990).

This experiment provides some of the least ambiguous evidence to date of mental state attribution in any nonhuman animal, and it does so using a transfer procedure with considerable potential (Heyes, 1993). However, two features of the experiment cast doubt on the conclusion that the sub-

jects' behavior was attuned to the trainers' visual access to the baiting procedure. First, since transfer was measured in a less than sensitive way, there may have been an undetected decrement in performance at the beginning of Stage 2 as the subjects learned to base their performance on a new set of cues. Second, it is not clear whether the chimpanzees were accustomed to dealing with "bagged" humans. In the unlikely event that they were, smooth transfer performance might have been due to prior learning that such people provide poor cues. On the other hand, the bagged trainer might have been a novel and rather alarming stimulus from which the chimpanzees averted their gaze, and this may have been responsible for their tendency to continue in Stage 2 to select the container indicated by the Knower.

Even if the experiment by Povinelli et al. (1990) is assumed to demonstrate discrimination on the basis of visual access, studies by Premack (1988) cast doubt on the conclusion that chimpanzees would make this discrimination because they attribute knowledge and ignorance to the trainers. In an experiment similar to that of Povinelli et al. (1990), Premack (1988) allowed chimpanzees to observe that a container had been baited in view of one trainer (the Knower) and not of another (the Guesser), and then offered the animals a choice of two strings to pull, one attached to each trainer. On having his string pulled, the Knower would step forward and tap the baited container, while the Guesser would tap an empty container, and once this had occurred, the chimpanzees were allowed to search one of the containers for food. Two of the four chimpanzees in this experiment learned to pull the string attached to the Knower, and to select for inspection the container indicated by that trainer. This suggests that these two animals spontaneously discriminated between the trainers on the basis of their visual access to the baiting procedure, and it is tempting to infer that they did this because they attributed knowledge of the food's location to the Knower. However, this is unlikely given the outcome of subsequent trials in which the procedure was identical except that the chimpanzees could see the location of food for themselves. Under these conditions, the animals continued to pull the string attached to the Knower before reaching out to claim their prize. This suggests that the chimpanzees selected the trainer that had visual access to baiting, not because they regarded him as a source of knowledge, but because reward had been contingent upon this action in the past.

Rhesus monkeys and human children have been tested using a procedure similar to the one applied by Povinelli et al. (1990) to chimpanzees (Povinelli & deBlois, 1992; Povinelli et al., 1991), but the results do not clarify the significance of the chimpanzees' transfer performance. The monkeys did not learn to choose the Knower during the first stage of the procedure, and consequently could not be given the transfer test (Povinelli et al., 1991). Four-year-old children were more likely than three-year-olds to search the container indicated by the Knower, and independent research has shown

that understanding of the relationship between perception and knowledge is usually acquired between the ages of three and four (e.g., Wimmer, Hogrefe, & Perner, 1988). However, among the children tested by Povinelli and deBlois (1992), those that consistently chose the Knower were no more likely than the others to answer correctly questions about how they, and the trainers, knew about the contents of the container.

Through their research on perspective taking, Povinelli and his associates are attempting to develop an equivalent for primates of the standard "false belief" tasks given to young children. In one of these, children witness the transfer of an object from one container to another, and are asked where an individual who was not present during the transfer will look for the object. In another, they observe the contents of a familiar candy box being replaced with, for example, pencils, and are asked what a person who did not witness the replacement will think is inside the box. Below the age of three and a half years, most children fail these tests, saying that the person who did not have visual access to the critical events will, nonetheless, search for the object at the correct location, or think that the candy box contains pencils. However, most four-year-olds say that the stooge will look for the object in the place where he or she last saw it, or think that the box has its usual contents, and they are consequently judged capable of attributing false beliefs (Perner, Leekam, & Wimmer, 1987). There can be little doubt that investigators of social cognition in primates need measures like these, which have relatively high reliability and construct validity. However, it remains to be seen whether a nonverbal test of mental state attribution, such as Povinelli's, can provide such a measure.

III. CONCLUSION

The foregoing review suggests that there is currently no compelling evidence of mental state attribution in nonhuman primates. The research reviewed in Sections II.A and II.B has not provided unequivocal evidence of imitation and mirror-guided body inspection in primates, and these behaviors are, in any event, unlikely to be indicative of mental state attribution. There can be little doubt that the members of many primate and nonprimate species exhibit sensitivity to social relationships and behavior that functions to deceive other animals (Sections II.C and II.E), but in every documented case the behavior could be based on one or a number of psychological processes other than mental state attribution. Finally, research on role taking and perspective taking (Sections II.D and II.F) has provided data suggestive of mental state attribution in a chimpanzee (Premack & Woodruff, 1978), and a transfer test procedure with considerable potential (Povinelli et al., 1990), but no thoroughly compelling evidence of mental state attribution.

In view of the low construct validity of imitation and mirror-guided body inspection, and the anecdotal character of work on social relationships and deception, it is apparent that little research to date has even had the potential to provide strong evidence of mental state attribution. Consequently, the current lack of such evidence indicates not that primates are unable to attribute mental states, but that inadequate empirical methodology has been used in addressing the question. Children's capacity to attribute mental states has been investigated experimentally with considerable success, so why has research on social cognition in primates relied so heavily on observational data?

Perspective taking is likely to be the most profitable focus for future research because it has relatively high construct validity and there is an experimental paradigm, involving conditional discrimination training followed by transfer tests (Povinelli et al, 1990), available for its investigation. In using this paradigm, it would be advisable to apply two or more transfer tests for each trained discrimination and, in each case, to measure transfer performance with as much sensitivity as possible (Heyes, 1993). This would typically involve confining attention to the first transfer trial, and/or withholding differential reinforcement during the transfer test phase.

The hypothesis that primates attribute mental states is intriguing and important; it has implications with respect to the evolution of intelligence, the epistemic status of "folk psychology," and animal welfare issues. Consequently, the hypothesis warrants thorough investigation, and it is hoped that a skeptical approach, of the kind adopted in this review, will stimulate the experimental work necessary for genuine evaluation.

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