

WellBeing International

WBI Studies Repository

4-1992

Comprehension of Role Reversal in Chimpanzees: Evidence of Empathy?

Daniel J. Povinelli
Yale University

Kurt E. Nelson
The Ohio State University

Sarah T. Boysen
The Ohio State University

Follow this and additional works at: https://www.wellbeingintludiesrepository.org/acwp_asie



Part of the [Animal Studies Commons](#), [Comparative Psychology Commons](#), and the [Other Animal Sciences Commons](#)

Recommended Citation

Povinelli, D. J., Nelson, K. E., & Boysen, S. T. (1992). Comprehension of role reversal in chimpanzees: evidence of empathy?. *Animal behaviour*, 43(4), 633-640.

This material is brought to you for free and open access by WellBeing International. It has been accepted for inclusion by an authorized administrator of the WBI Studies Repository. For more information, please contact wbisr-info@wellbeingintl.org.



Comprehension of Role Reversal in Chimpanzees: Evidence of Empathy?

Daniel J. Povinelli¹, Kurt E. Nelson², and Sarah T. Boysen^{2,3}

¹ *Yale University*

² *Ohio State University*

³ *Emory University*

ABSTRACT

Four chimpanzees, *Pan troglodytes*, were individually trained to cooperate with a human partner on a task that allowed both participants to obtain food rewards. In each chimpanzee-human dyad, one of the participants (the informant) could see which pair of food trays on a four-choice apparatus was baited, but had no means of obtaining it. The other participant (the operator) could pull one of four handles to bring a pair of the trays within reach of both participants, but could not see which choice was correct. Two of the chimpanzees were initially trained as informants and adopted spontaneous gestures to indicate the location of the food. The two other chimpanzees were trained as operators and learned to respond to the pointing of their human partner. After the chimpanzee subjects reached near perfect performance, the roles in each chimpanzee-human dyad were reversed. Three of the four chimpanzees showed immediate evidence of comprehension of their new social role. The results are discussed in the context of cognitive empathy and the potential for future research on social attribution in non-human primates.

Genetics, learning and cognition have all been implicated as sources of human and animal behaviour. In particular, cognition has become an important focal point of research in most of the behavioural sciences (Gardner 1986). However, the study of one of the most widely investigated cognitive processes in humans, social attribution, remains relatively neglected in behavioural research with animals. Social psychologists developed attribution theory as part of an effort to understand how people perceive and explain the actions of others, and how these perceptions influence their behaviour (Heider 1958; Harvey & Weary 1981). Social and self-attributions can be thought of as perceptions and inferences about the mental states of others or oneself, respectively (Harvey & Weary 1981).

The issue of attribution in animals has not been completely neglected, however, and a number of researchers have experimentally approached the issue in different ways. Gallup's (1970) demonstration of self-recognition in chimpanzees, *Pan troglodytes*, offered evidence of a self-concept, suggesting that these animals may be capable of some forms of self-attribution. Menzel's (1974) experiments with captive chimpanzees in large outdoor enclosures laid the groundwork for investigating social attribution of emotions and knowledge. More recently, Cheney & Seyfarth (1990a, b) have experimentally explored the

communication system of vervet monkeys, *Cercopithecus aethiops*, in an attempt to understand how these animals perceive their social world. Premack, however, must be credited with establishing the first systematic effort to link traditional animal intelligence testing paradigms to attribution theory in social psychology (Premack & Woodruff 1978; Premack 1986, 1988). Premack & Woodruff's (1978) experiments with the adult female chimpanzee Sarah provided intriguing experimental evidence that some non-human primates might be capable of the attribution of intention. They concluded that chimpanzees possess an ability to impute mental states to others, what they refer to as a 'theory of mind' (Premack & Woodruff 1978).

In the past two decades, there has been a parallel resurgence of interest in child and non-human primate social cognition (see Miller & Aloise 1989 and Cheney & Seyfarth 1990a. for reviews of each respective field). Topics such as intentional deception, cognitive empathy, belief and knowledge attribution have all become important areas of investigation in both fields. Developmental psychologists have typically relied on both experimental manipulations and more naturalistic observations of linguistic utterances and behavior in an effort to establish the ontogeny of specific attributional processes in infancy (for examples see review by Miller & A loise 1989). Unfortunately, an analogous tradition in the study of non-human primate attributional processes is only beginning to emerge slowly. Aside from the work of Premack, and a few recent studies (Cheney & Seyfarth 1990b; Povinelli et al. 1990, 1991), most reports have either been of a naturalistic type (often a series of illustrative incidents used to argue for the possible presence of attributional processes) or strictly theoretical investigations (for example. Gallup 1982; Dennett 1983). Premack (1988) has recently stressed the need for careful experimental approaches to these issues in order to rule out competing explanations based on more parsimonious assumptions.

Thus, there is clearly a need to establish a link between experimental and naturalistic approaches to understand social attribution in non-human primates. Developmental psychologists have already outlined many intriguing areas of research that might be investigated in non-human primates and their work offers important clues for designing rigorous experimental approaches. For example, we recently reported the results of a preliminary investigation of visual perspective taking and knowledge attribution in chimpanzees that was modelled after comparable research with children (Povinelli et al. 1990; see also the description of an analogous experiment by Premack 1988). One important area of social attribution research in young children has been the topic of cognitive empathy or role taking. Mead (1934) explored this phenomenon in detail and defined role taking as the ability to adopt the viewpoint of another individual. This included emotional, visual and cognitive perspectives. Role taking has generally become regarded as a strictly cognitive skill whereby an individual takes the perspective of another individual, and has often been referred to as cognitive empathy or cognitive perspective taking (Sarbin 1954; Flavell et al. 1975). Role playing, on the other hand, is generally seen as the enactment of a particular social role which is seen in the development of children's play behaviour (Sarbin 1954). In this sense, role taking is viewed as a cognitive process that may be used for role playing. Role taking has long been viewed as an important component in the development and utilization of communication skills in young children (Sachs & Devin 1976; Wellman & Lempers 1977).

In this paper, we describe the results of an experiment designed to determine whether chimpanzees are capable of using a simple form of cognitive empathy to enact a social role with which they had no prior direct experience. Our strategy was to pair each chimpanzee subject with a human partner on a cooperative communication task that required each participant to perform a different role. Once the chimpanzees had learned their initial role, we then reversed the roles of the participants to determine if the chimpanzees could immediately perform their new role as accurately as their old one. The study was inspired by an earlier experiment with young rhesus monkeys, *Macaca mulatta*, as subjects (Mason & Hollis 1962).

METHODS

Subjects and Housing

The subjects were two male and two female chimpanzees housed at the Primate Cognition Project of The Ohio State University. At the time of the study their ages were, Sheba, 7 years; Kermit 9 years; Darrell 9-5 years; and Sarah, 28 years. Sheba, Darrell and Kermit had participated in a variety of previous investigations related to learning and cognition. Prior to her arrival at the Primate Cognition Project, Sarah had been the subject of over two decades of cognitive studies. (A more complete description of the subjects' prior histories can be found in Povinelli et al. 1990.)

Apparatus

The apparatus used in the investigation was a modified version of a communication apparatus designed by Mason & Hollis (1962). Following Mason & Hollis, we refer to one side of the apparatus as the informant side, and the other as the operator side (Fig. 1). The operator side had four handles that controlled the movement of four paired food trays. Removable, opaque shields were placed inside the trays during the latter phases of the experiment to prevent individuals on the operator side from seeing their contents. From the informant side, however, the contents of the trays remained clearly visible. When one of the handles was pulled, the corresponding pair of trays moved in opposite directions to within reach of the participants (Fig. 1). The informant side had no such handles, preventing the individual on this side from controlling the operation of the trays.

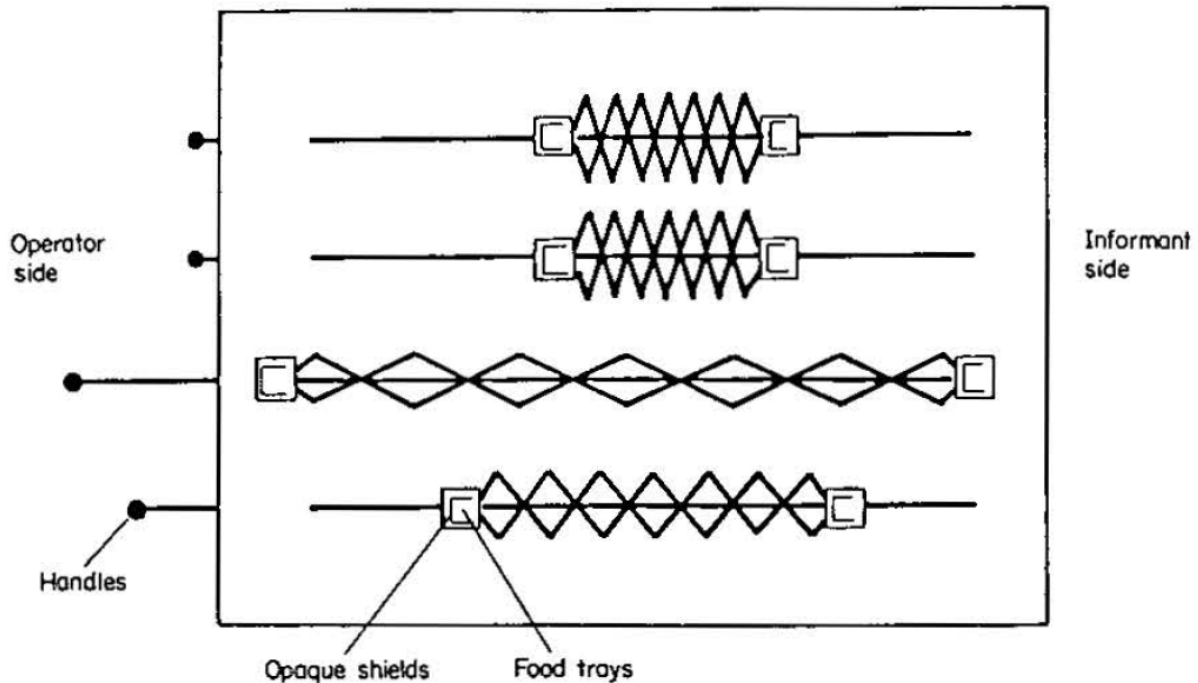
Procedure

The procedure was modelled after experiment 1 of Mason & Hollis (1962). During pretraining, the chimpanzees were individually trained to operate the handles that controlled the food trays. The operator side of the apparatus was placed against the front of the subject's cage so that the subject could manipulate the handles. Each animal was given three informal sessions (40-57 total trials) with the apparatus during which they watched an experimenter place a food reward in one of the food trays on the operator side of the apparatus. With differing degrees of prompting, all subjects quickly learned to pull the handle corresponding to the correct food tray and retrieve the reward. As in all subsequent phases, the placement of food was block-randomized so that each position was baited an equal number of times in the first 10 trials and the last 10 trials and no position was correct more than twice consecutively. A variety of food rewards were used, most consisting of small pieces of fresh banana. In addition, vocal praise was given after correct trials.

Phase 1 (retrieval training) of the experiment was conducted to equate each subject's reliability in terms of operating the apparatus. At the start of each trial, a hood was placed over the food trays that prevented the chimpanzee operator, but not the experimenter, from seeing the food trays. The experimenter then hid a food reward in one pair of the trays either before, during, or after a number of false baitings. A second experimenter then removed the hood. The task was simply for the chimpanzee to see which pair of trays contained food and then pull the appropriate handle. When the trays slid into reach, both the operator and the experimenter ate their reward. The subjects were given one session (20 trials) per day until they performed for 2 consecutive days at a rate of at least 90% correct. In this phase, the subjects were allowed to touch as many handles as they wanted, but if they began to pull an incorrect handle the trial was scored as incorrect, even if they immediately reoriented to the correct handle. However, to ensure their cooperation, the subjects were usually allowed to pull the correct handle after making a mistake.

In phase 2 (role training) the apparatus was slightly modified by placing the opaque shields in all food trays to prevent individuals on the operator side from seeing if the trays contained food as described earlier. The chimpanzees were divided into two groups based on their role: informants (Kermit and Sheba), and operators (Sarah and Darrell). Each animal was then paired with the same human experimenter who assumed the opposite role, thus forming a total of four chimpanzee- human dyads.

Figure 1. Communication apparatus used in the experiment. Four pairs of food trays were controlled by pulling the handles on the operator side of the apparatus. During pretraining and phase 1, the opaque shields were removed from the apparatus. During phases 2 and 3 the shields were placed into the food trays to obscure their contents when viewed from the operator side.



For the chimpanzees designated as informants (Sheba and Kermit), each trial began as they watched the second experimenter place a hood over the food trays which prevented their human partner (the operator), but not themselves, from seeing where the food was hidden. The subjects then watched as the second experimenter placed food into one of the dishes while the human operator faced away from the apparatus and covered his ears with his hands to prevent him from receiving any potential visual or auditory cues about the location of the reward. After the food had been hidden, the second experimenter signalled the human operator to turn around and face the apparatus and the hood was removed. The human operator then waited for some manual gesture from the chimpanzee informant as to the possible location of the food. The operator made a choice of which handle to pull based on these cues from the chimpanzee. All behaviour by the chimpanzee informants was spontaneous (except for one trial for each subject, see Results); although if the subject made no obvious response within about 15 s the operator asked the subject vocally which of the trays contained the food (in order to encourage them to respond). After the operator pulled a handle, he immediately looked behind the screen. If food was present, he conspicuously ate the reward while the subject simultaneously obtained and ate their own reward in the opposite food tray. The chimpanzee informants were scored as correct if the operator made a correct choice, and incorrect if he did not.

For the chimpanzees designated as operators (Darrell and Sarah), each trial began as the hood was lowered (blocking their view of the food trays). Next, the human informant hid food in one of the pairs of food trays either before, during or after several false baitings and then pointed to the correct pair of trays. The second experimenter then removed the hood. The pointing was generally modelled after Sheba's pointing in phase 2 which began prior to the first session with the operators. A correct response was scored on each trial that the chimpanzee operator pulled the appropriate handle and displaced the cup from the correct food tray before looking inside any of the others. An incorrect response was scored as soon as the subject touched an incorrect tray. The human informant waited until the chimpanzee operator had looked inside his or her tray before removing and eating his own reward. For both operators and informants, this phase was terminated after a criterion of 85% correct or better for three consecutive days was met.

To determine what the subjects had learned about the role of their partner, phase 3 (role reversal) was conducted. On the day immediately following their final day of role training, we set up the apparatus as usual for each subject. However, before beginning the test session, we simply turned the apparatus around while the subject watched, thus reversing the roles in each informant-operator dyad. The chimpanzees' performances on the first session of 20 trials in their new role were compared with their last session in their previous role for evidence of significant transfer between the two roles.

RESULTS

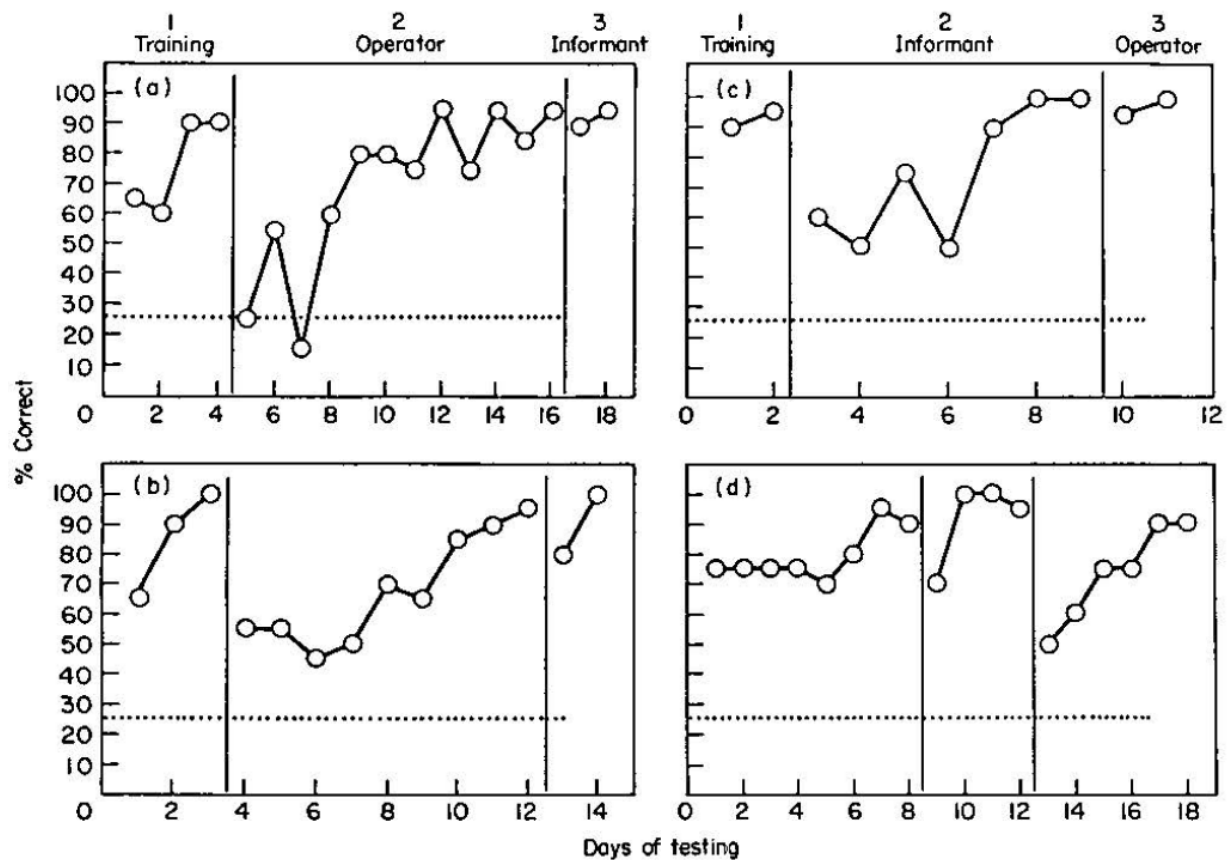
The results of the retrieval training phase indicate the ease with which the subjects learned to pull the handles which operated the correct food tray (Fig. 2a-d). Kermit (Fig. 2d) took considerably longer to reach the same performance level as the others, but all subjects began their role training phase with a roughly equivalent ability to operate the apparatus correctly.

The results of the role training phase indicate clear learning curves for all of the subjects. Three of the four subjects displayed performances well above chance in their first session (Sheba, $\chi^2 = 13.07$, $N = 20$, $df = 1$, $P < 0.001$; Darrell, $\chi^2 = 9.6$, $N = 20$, $df = 1$, $P < 0.005$; Kermit, $\chi^2 = 21.6$, $N = 20$, $df = 1$, $P < 0.001$), whereas Sarah performed at exactly chance levels during her first session. The informants met the criterion slightly quicker than the operators (four and seven sessions versus nine and 12 sessions). However, given the small number of subjects it would be premature to draw definitive conclusions concerning the relative ease of learning the different roles. One of the subjects, Kermit, began his role training phase as an informant by pounding on the surface of the apparatus with such force that it was necessary to restrain this spontaneous gesture by holding his hand against the surface of the apparatus. Unfortunately, in doing this on one trial we may have inadvertently taught him the correct response of pointing. This does not affect the primary results of the experiment, although it may explain his poor performance on the role reversal task (see Discussion).

The critical results of this experiment can be seen by comparing the performance of each subject on their last session of their role training phase (phase 2) with their first session of the role reversal phase (phase 3). We examined the performances of all four subjects during these two sessions and interpreted the absence of a significant drop in performance as evidence of transfer. Three of the four subjects showed immediate transfer between the two phases by showing no significant interaction between their success and failure on the last day of role training and their success and failure on the first day of role reversal (Fig. 2, Fisher's exact test: Darrell, $P = 0.17$; Sarah, $P = 0.50$; Sheba, $P = 0.50$). In contrast to such evidence of immediate comprehension, Kermit showed a significant drop in performance between his last training session and his first role reversal session ($\chi^2 = 10.15$, $N = 40$, $df = 1$, $P < 0.001$).

Additional support for Darrell, Sheba and Sarah's immediate comprehension comes from an examination of their first few trials within the initial role reversal session. As an informant on the first day of role reversal, Sarah produced accurate pointing to the correct location on the first 13 trials before making the first of her two errors. In his first session as an informant, Darrell produced a novel and unambiguous form of pointing by inserting the tip of his middle finger in the appropriate slot along which the food trays moved. As an operator, Sheba's first six choices were all correct before she made her only error in 20 trials.

Figure 2. Performance by subject across all three phases of the experiment. Graphs a (Sarah) and c (Sheba) display the results for the two chimpanzees that were trained as operators and later tested as informants; b (Darrell) and d (Kermit) depict the results for the two subjects that were trained as informants and later tested as operators. Data are presented by session, which each consisted of 20 trials. Dotted horizontal lines represent levels expected by chance.



DISCUSSION

The results of this study are consistent with the hypothesis that chimpanzees are capable of roleplaying and thus some form of cognitive empathy. Sheba, Sarah and Darrell showed immediate transfer between their first and second roles, despite having never directly experienced it. The immediate production (Sarah and Darrell) and comprehension (Sheba) of pointing supports our working hypothesis that during the role training phases, the subjects learned the requirements of both roles through social attribution, thus enabling them to immediately perform their new role. The chimpanzees trained as operators, for example, learned not only to respond to pointing by their human partner, but the results suggest that they

may also have demonstrated role-taking by learning the intentional significance of such pointing from the perspective of the opposite role. Similarly, Sheba (as an informant) as well as learning that pointing elicited a reward, also appears to have understood the intentional effect that such pointing had on her human partner. In essence, we raise the possibility that the chimpanzee may have understood pointing as an arbitrary symbol to represent intentions.

Kermit's failure to perform in a manner similar to that of the other chimpanzees may be the result of our being forced to restrain his spontaneous pounding gestures on the first day of testing. In showing him the response pattern that elicited a reward (see Results), we may not have allowed him to learn, through trial and error, the symbolic meaning of pointing within the context of the cooperative task. We suggest, as did Kohler (1927), that 'trying around' (as he put it) may be an essential element of arriving at insightful solutions to problems. We suspect that such efforts are as important in solving problems involving social attributions as those dealing with physical relationships. If we did inadvertently deprive Kermit of this opportunity by showing him a correct solution, then this may account for why he only gradually responded accurately to pointing in his role reversal phase. Some support for this explanation of Kermit's behaviour comes from his learning curve in phase 2 (Fig. 2d). In sharp contrast to the other subjects, Kermit was responding at criterion level by the beginning of his second session of role training. On the other hand, Kermit's performance may reflect individual attentional and/or cognitive differences.

The overall results reported here are quite different from those obtained by Mason & Hollis (1962) who discovered little evidence of role reversal comprehension in young rhesus monkeys. They concluded that for their monkeys, 'communication learning appeared to be specific to the role in which the individual was trained, and when the roles were reversed no evidence of transfer was obtained' (Mason & Hollis 1962, page 220). The potential that species differences may exist in this capacity is a matter of some theoretical importance (Gallup 1982). However, the current evidence should not be interpreted as evidence supporting an intellectual difference between chimpanzees and rhesus monkeys, both because of the young age and the abnormal rearing histories of the macaques tested by Mason & Hollis. In addition, there are important methodological differences between our study and theirs.

For example, for practical reasons we chose to have the chimpanzees work with a human partner, rather than another chimpanzee. This may have had two effects on the results. First, having an intentional human informant provided the chimpanzees with stable, accurate information about the location of the food, and thus may have facilitated their comprehension of the nature of the task. It is clear from Kermit and Sheba's initial performance as informants in the role training phase that had we relied on chimpanzee-chimpanzee dyads, such stable information would not have been present (at least initially), thus confounding early attempts of chimpanzee operators to discover the relevant cues to solve the task. The second potential effect of using human partners was to introduce operators into the task who we already knew would interpret the gestures of the chimpanzee informant in an intentional fashion. In other words, the human operator automatically interpreted the chimpanzee gestures in an intentional manner, regardless of whether they were intentional. Although this is an important theoretical point, we regard it as a minor issue in our study because we examined both production and comprehension of pointing in the contexts of both role training and role reversal.

An important consideration for the interpretation of our results is the role of pointing in chimpanzee behaviour. Some of the pointing gestures we observed were similar to food begging gestures observed in both wild and captive chimpanzees (Goodall 1968; Teleki 1973). For example, Sarah's pointing consisted of the open hand with the palm face up commonly described in food begging situations. Sheba's gestures were typically different, however. She typically extended her fingers vertically, without the open palm. Darrell used a novel form of pointing by using his middle finger to touch the tip of the slot in front of the

correct food tray. This pointing behaviour mirrored gestures used by each animal in other contexts, witnessed both before and after this study.

It is possible to argue that our results show only that chimpanzees can both produce and comprehend pointing, and, because chimpanzees raised with humans often point in a variety of contexts, our results may reveal nothing about cognitive empathy (for a discussion of chimpanzee pointing behaviour, see Povinelli 1991). The fact that chimpanzees can point spontaneously is shown by Sheba's above chance performance in the first session of her role training phase. (Kermit showed a similar pattern, but his data are difficult to interpret as discussed previously.) Similarly, Darrell comprehended pointing significantly better than could be expected by chance in his first session of role training. However, both Sheba's initial production, and Darrell's initial comprehension, were incomplete and sporadic for a number of sessions before they began steady improvement toward criterion performance.

In sharp contrast, Fig. 2a-c reveals that during the role reversal phase, Sheba's comprehension, and Darrell and Sarah's production, were immediate and stable from the beginning of the first session. In addition, our main comparison only focused on how well the chimpanzees transferred from their criterion performance at the end of their role training to their first session of role reversal. This was done to provide a conservative estimate of their immediate comprehension of their new roles. In other words, we biased our results against finding a significant effect by considering only their transfer into the role reversal phase, as opposed to asking merely whether they performed above chance. Thus, the fact that some of the subjects appeared to imperfectly point or comprehend pointing from the outset does not invalidate our comparisons.

In general, this approach could be considerably strengthened by using larger sample sizes, and thereby provide a statistical comparison of the performance of informants and operators in role training to informants and operators in role reversal. With enough animals, the performances of the animals originally trained as informants, for example, could be used as a control group for the animals that became informants in the role reversal condition. Our current results in this regard are strongly suggestive, but not definitive. Indeed, the spontaneous comprehension of pointing is intriguing in its own right, since the emergence of this behaviour in young children may signal the transition from pointing as mere actions, to the understanding of gestures as intentional gestures, aimed at directing the attention of other individuals. Murphy & Messler (1977) have also argued that this behaviour may then serve to assist the child in developing an understanding of the perspectives of others (for a slightly different perspective see Leung & Rheingold 1981).

These results provide preliminary support for the hypothesis that chimpanzees are capable of using the cognitive skill of role taking or cognitive empathy to engage in simple role playing situations. Further evidence in support of the hypothesis could be obtained by training chimpanzees to perform similar cooperative games with two clearly defined and distinct roles that did not involve pointing at food rewards. A role reversal technique could then be used to assess their ability to perform their partner's role. Current research is underway to determine if adult rhesus monkeys are capable of role-taking using the experimental design that we have reported in this study. It is hoped that such studies will eventually help to evaluate theories concerning the distribution of attributional skills in non-human primates based on species differences in self-recognition (Gallup 1982, 1983).

ACKNOWLEDGMENTS

This research was supported by a NSF Graduate Fellowship to D.J.P. and NSF Grant BNS-8820294 to Alison F. Richard and D.J.P. The research was also supported in part by NIMH Grant R03 MH44022-01 and by NSF Grant BNS-8820027 to S.T.B. Two of the chimpanzees are on loan from the Yerkes Regional

Primate Research Center (supported by Base Grant RR-00165, Division of Research Resources), Emory University. The Ohio State University Laboratory Animal Center and Yerkes Primate Center are fully accredited by the American Association for Laboratory Animal Care. We thank G. Berntson, G. Gallup, Jr, M. Novak and A. Richard for their advice and support, and for providing comments on a draft of this manuscript. M. Schwartz and B. Dobkin offered continuous encouragement throughout the project. TTM Associates, Inc. provided assistance in designing the apparatus used in the study.

REFERENCES

- Cheney, D. L. & Seyfarth, R. M. 1990a. *How Monkeys See the World*. Chicago: University of Chicago Press.
- Cheney, D. L. & Seyfarth, R. M. 1990b. Attending to behaviour versus attending to knowledge: examining monkeys' attribution of mental states. *Anim. Behav.*, 40, 742- 753.
- Dennett, D. 1983. Intentional systems in cognitive ethology: the 'Panglossian Paradigm' defended. *Behav Brain Sci.*, 6, 343-355.
- Flavell, J. H., Botkin, P. T., Fry, C. L., Jr, Wright, J. W. & Jarvis, P. E. 1975. *The Development of Role-taking and Communication Skills in Children*. Huntington, New York: Robert E. Krieger.
- Gallup, G. G., Jr. 1970. Chimpanzees: self-recognition. *Science*, 167, 86-87.
- Gallup, G. G., Jr. 1982. Self-awareness and the emergence of mind in primates. *Am. J. Primatol.*, 2, 237-248.
- Gallup, G. G., Jr. 1983. Toward a comparative psychology of mind. In: *Animal Cognition and Behavior* (Ed. by R. E. Mellgren), pp. 473- 510. New York: North Holland Publishing.
- Gardner, H. 1986. *The Mind's New Science*. New York: Basic Books.
- Goodall, J. 1968. Expressive movements and communication in free-ranging chimpanzees: a preliminary report. In: *Primates: Studies in Adaptation and Variation* (Ed. by P. Jay), pp. 313-374. New York: Holt, Rinehart & Winston.
- Harvey, J. H. & Weary, G. 1981. *Perspectives on Attributional Processes*. Dubuque, Iowa: W. C. Brown.
- Heider, F. 1958. *The Psychology of Interpersonal Relations*. New York: John Wiley.
- Kohler, W. 1927. *The Mentality of Apes*. London: · Routledge & Kegan Paul.
- Leung, E. & Rheingold, H. 1981. Development of pointing as a social gesture. *Devl Psychol.* , 17, 215-220.
- Mason, W. A. & Hollis, J. H. 1962. Communication between young rhesus monkeys. *Anim. Behav.*, 10, 211- 221.
- Mead, G. H. 1934. *Mind, Self and Society*. Chicago: University of Chicago Press.
- Menzel, E. W., Jr. 1974. A group of young chimpanzees in a one-acre field. In: *Behavior of Nonhuman Primates: Modern Research Trends. Vol. 5* (Ed. by A. Schrier & F. Stollnitz), pp. 83-153. New York: Academic Press.
- Miller, P. H. & Aloise, P. A. 1989. Young children's understanding of the psychological causes of behavior: a review. *Child Dev.*, 60, 257- 285.
- Murphy, C. & Messler, D. 1977. Mothers, infants and the pointing gesture. In: *Studies in Mother- Infant Interaction* (Ed. by H. R. Schaffer), pp. 325- 353. London: Academic Press.
- Povinelli, D. J. 1991. Social intelligence in monkeys and apes. Ph.D. thesis, New Haven, Connecticut: Yale University.
- Povinelli, D. J., Nelson, K. E. & Boysen, S. T. 1990. Inferences about guessing and knowing in chimpanzees (*Pan troglodytes*). *J. comp. Psychol.*, 104, 203- 210.
- Povinelli, D. J., Parks, K. A. & Novak, M. A. 1991. Do rhesus monkeys (*Macaca mulatto*) attribute knowledge and ignorance to others? *J. comp. Psychol*, 105, 318- 325.
- Premack, D. 1986. *Gavagai*. London: Cambridge University Press.

- Premack, D. 1988. 'Does the chimpanzee have a theory in mind' revisited. In: *Machiavellian Intelligence: Social Expertise and the Evolution of Intellect in Monkeys Apes and Humans* (Ed. by R. Byrne & A. Whiten), pp. 160-179. New York: Oxford University Press.
- Premack, D. & Woodruff, G. 1978. Does the chimpanzee have a theory of mind? *Behav Brain Sci.*, 1, 515-526.
- Sachs, J. & Devin, J. 1976. Young children's use of age-appropriate speech styles in social interaction and role-playing. *J. Child Lang.*, 3, 81-98.
- Sarbin, T. R. 1954. Role theory. In: *Handbook of Social Psychology. Vol. 1* (Ed. by G. Lindzey), pp. 223-258. Cambridge, Massachusetts: Addison-Wesley.
- Teleki, G. 1973. *The Predatory Behavior of Wild Chimpanzees*. East Brunswick, New Jersey: Bucknell University Press.
- Wellman, H. M. & Lempers, J. D. 1977. The naturalistic communicative abilities of two-year-olds. *Child Dev.*, 48, 1052-1057.