

Role reversal by rhesus monkeys, but no evidence of empathy

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Abstract. Four adult rhesus monkeys, *Macaca mulatta*, were individually trained to interact with a human partner on a social task. In each macaque–human dyad, one of the participants (the informant) could see where a food reward was hidden on an apparatus, but was unable to retrieve it. The other participant (the operator) could operate the apparatus by pulling one of three handles, but could not see where the food was hidden. Two of the macaques were initially trained to be informants, and their behaviour was shaped until they adopted an unambiguous ‘pointing’ gesture in front of the correct cup. The other two were trained as operators and responded to the pointing gestures of their human partner. The subjects were trained until their performances were almost errorless. Finally, the operator–informant roles in each dyad were reversed. None of the subjects showed an immediate comprehension of their new role. This result contrasts with previous research with chimpanzees, *Pan troglodytes*, and indicates potentially important species differences in social intelligence.

By the middle of their second year of life, human children display a remarkable ease in adopting a variety of real and imaginary social roles (Flavell et al. 1975; Sachs & Devins 1976; Watson & Fischer 1980; Dunn & Dale 1984). Traditionally, these patterns of behaviour have been treated as instances of symbolic (or pretend) play, and have been explained, at least partially, in terms of the child’s growing ability for empathy, or social understanding. Mead (1934), for example, viewed these symbolic forms of social play in young children as signs of their increasing capacity for role-taking, or adopting the perspectives of others. Do other animals also develop such capacities? This question is especially important in light of the recent attention that non-human primates have garnered as potential ‘natural psychologists’ (Humphrey 1980). The possibility that organisms other than humans, especially non-human primates, may be capable of reasoning not only about observable behaviour, but about states of mind as well, has been raised by a number of different investigators (Romanes 1882; Premack & Woodruff 1978; Humphrey 1980; Whiten & Byrne 1988; Cheney & Seyfarth 1990a). The issue, as Premack & Woodruff (1978) orig-

inally described it, is whether or not they possess an ability to attribute mental states to themselves and to others.

Several lines of experimental and naturalistic evidence suggest that chimpanzees, *Pan troglodytes*, may possess certain self- and social-attribitional processes in common with humans (Gallup 1970, 1985; Premack & Woodruff 1978; Woodruff & Premack 1979; Goodall 1986; de Waal 1986; Premack 1988; Povinelli et al. 1990, 1992). Collectively, these results suggest that chimpanzees and humans may share at least some portion of a cognitive developmental pathway involved in the attribution of mental states to themselves and others (Povinelli 1991). It remains unclear if these processes represent primitive features of primate cognition, or if they are exclusively derived in either the great ape–human or exclusively human lineages. Amidst this uncertainty, tension has emerged between research in the field, which suggests that some primates may possess these abilities and research in laboratories which finds little evidence for such abilities in primates other than chimpanzees (e.g. Cheney & Seyfarth 1990b; Povinelli et al. 1991). However, field research addressing these issues remains too anecdotal and uncontrolled, while studies in the laboratory are still in their infancy.

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At least one researcher has addressed the issue of the distribution of self- and social-attribution in the animal kingdom and has explicitly predicted that most species of animals, indeed, most species of primates do not, in fact, reason about mental states at all (Gallup 1982, 1985). Gallup (1970) discovered that chimpanzees are capable of recognizing themselves in mirrors, and subsequent research has extended this finding to include orang-utans, *Pongo pygmaeus*, and at least one gorilla, *Gorilla gorilla*, (see Povinelli 1991 for a review). Nearly 20 other primate species including prosimians, Old and New World Monkeys, and gibbons have failed to show similar evidence of self-recognition. This difference is potentially of profound psychological importance, Gallup argues, since self-recognition in mirrors presupposes the presence of self-awareness, which he defines as the ability of an organism to become the object of its own attention (Gallup 1982). Thus, Gallup hypothesizes that organisms capable of the behaviour of self-recognition possess the psychological capacity to reflect on their own experiences.

By itself, equating self-recognition and self-awareness adds little to our understanding of animal behaviour per se. However, Gallup (1982, 1985) has developed a model which explicitly predicts that organisms capable of self-recognition ought to show specific behaviour not possible by organisms that do not recognize themselves. Gallup believes that organisms capable of self-recognition possess a capacity for introspection, and hence are able to use their own experiences as a means of inferring similar mental experiences in others, ultimately resulting in the development of a unique class of behaviour. In particular, he has predicted that chimpanzees and orang-utans (and perhaps some gorillas) ought to show evidence of behaviour based on self- and social-attribution such as sympathy, intentional deception, attribution of intention and responsibility, and empathy (Gallup 1985, 1991). The argument that humans use their own private experiences as a source of inferential knowledge of others is not new, but what is startlingly original is Gallup's application of this idea in the context of comparative behavioural biology (Povinelli 1991). Gallup's model stands in stark relief to those researchers who see no heuristic value in introducing mental concepts such as self-awareness in the field of animal behaviour (e.g. Epstein et al. 1980, 1981).

In an attempt to gain a phylogenetic perspective on the attributional capacities of non-human primates, and in the process subject Gallup's model to a preliminary test, we and our colleagues conducted a series of comparative studies of knowledge attribution in chimpanzees, rhesus monkeys, *Macaca mulatta*, and 3- and 4-year-old human children. The results provided evidence consistent with the view that the chimpanzees understood the causal connection between 'seeing' and 'knowing' (Povinelli et al. 1990). That is, the chimpanzees behaved as if they understood that vision can create knowledge states in other organisms. Premack (1988) has also reported data which supports this hypothesis. In addition, our work with 3- and 4-year-old children provided corroboration that the chimpanzees' performance was achieved through knowledge attribution, as opposed to general learning processes (Povinelli & deBlois, in press). Three-year-olds performed quite poorly on our task, whereas 4-year-olds did quite well. This result matches findings in previous investigations with young children which have relied upon linguistic measures (see Perner 1991 for a review). This is important because it strongly suggests that in order to behave successfully on our non-linguistic task, an organism must understand the relation between 'seeing' and 'knowing'. Finally, in direct contrast to the chimpanzees and older children, rhesus monkeys showed no evidence of understanding the difference between someone who witnessed an event and someone who did not, despite the fact that we offered the subjects extended training and used paradigms explicitly designed to make the task as easy as possible for them (Povinelli et al. 1991 see also Cheney & Seyfarth 1990b).

Recently, we (1992) replicated with chimpanzees a portion of an experiment conducted with rhesus monkeys by Mason & Hollis (1962) with the specific aim of determining whether chimpanzees were capable of a simple form of role-taking, or cognitive empathy. Four chimpanzees were trained to cooperate with a human partner on a social task in which each partner had to perform a specific role. Three of the four chimpanzees showed evidence of immediate comprehension of their partner's role when their roles were reversed. In contrast, Mason & Hollis (1962) reported that their rhesus monkeys showed no evidence of an ability to adopt the roles of their partner when the roles were reversed. This might appear to argue for species differences between chimpanzees and rhesus monkeys

Table I. Experimental design

| Subject | Phase | | | | |
|---------|--------------|----------------------|------------------------|-----------------|-----------------|
| | Pre-training | 1 Retrieval training | Pointing comprehension | 2 Role training | 3 Role reversal |
| Sundari | + | + | + | Operator | Informant |
| Fuzzy | + | + | + | Operator | Informant |
| Tuck | + | + | - | Informant | Operator |
| Stud | + | + | - | Informant | Operator |

+ : subject participated in procedure; - : subject did not participate in procedure.

However, given the young age and impoverished early rearing experiences of Mason & Hollis' (1962) original rhesus monkey subjects, as well as procedural differences between the experiments, it would be premature to conclude that species differences may exist in this capacity. In this paper, we report an experiment that was conducted to replicate the chimpanzee experiment using adult rhesus monkeys. The results are discussed in the context of potential species differences in attributional abilities and Gallup's (1982, 1985) model which prompted this research.

METHODS

Subjects and Housing

The subjects were three male (Tuck, Stud, Fuzzy) and one female (Sundari) rhesus macaques from two different social groups at the University of Massachusetts Primate Laboratory. At the time of the study, Tuck was 15 years old, Stud and Fuzzy were 20, and Sundari was 14. All of the subjects had extensive exposure to human observers and caretakers over the course of their lives and had previously participated in a variety of learning studies. A more detailed history of the subjects used in this study is provided elsewhere (Povinelli et al. 1991).

Apparatus

In this investigation we used a smaller version of the apparatus described previously for chimpanzees (Povinelli et al. 1992). It consisted of a shallow box measuring 102 × 61 × 25 cm. There were two sides to the apparatus, one with handles (the operator side) and one without handles (the informant

side; Fig. 4). We mounted four paired food trays that were each attached to extendable arms to the surface of the box. Each pair of food trays was attached to a separate handle on the operator side of the apparatus. Pulling each handle moved the corresponding pair of food trays in opposite directions, one to the operator side and the other to the informant side. During the course of pre-training one pair of food trays was removed, and left removed, for the remainder of the experiment.

Procedure

We conducted the experiment in a series of steps (summarized in Table I) as follows.

Pre-training

In the first stage of pre-training, we placed the operator side of the apparatus adjacent to the monkeys' home cages so that the handles were within reach of the monkeys. Gradually, some of the monkeys were trained to pull the handles and retrieve food rewards placed in the food trays. At the end of this stage, seven adult subjects had been trained to pull the handles to retrieve food rewards and were therefore selected for further study. A variety of food rewards was used including raisins, grapes, peanuts, and 'Fig Newtons' (biscuits).

During the second stage of pre-training, we daily transported each subject to an individual cage, where they were tested separately. All of the subjects were familiar with the transportation procedure, as well as the individual cages. However, the monkeys required some time to refamiliarize themselves with the operation of the apparatus in this new setting (range = 1-9 sessions). We considered the subjects familiarized once they pulled a

handle on 75% of trials in which a reward had been placed in a food tray. Four of the subjects met this criterion and were selected to be the subjects of the main experiment. Finally, each of the four subjects was trained to delay pulling the handles until food was placed into a tray, and were familiarized with a procedure in which only one tray would be baited on a given trial.

Phase 1: retrieval training

In the first phase of the experiment, the monkeys were trained to scan the apparatus for a baited tray and pull the corresponding handle. At the start of each trial, one experimenter stood behind the apparatus and showed the monkeys a food reward by holding it up in front of them. A second experimenter then placed a large cardboard screen in front of the monkey, preventing her/him from seeing out of the cage. The first experimenter placed the food in one of the trays and lowered the screen, allowing the animal visual and manual access to the apparatus. As soon as the subject began to pull a handle, we scored the animals as correct or incorrect. If the subject was correct, the monkey retrieved the reward when the food tray came within reach. If the subject was incorrect, we ended the trial. In order to keep the subjects motivated, we occasionally allowed them (in the beginning of this phase only) to pull the correct handle and retrieve the reward after making an initial mistake. Such trials were still scored as incorrect.

Because the first monkey (Tuck) that underwent this training showed a plateau in his learning curve at a relatively low level, we altered the apparatus slightly by removing the fourth handle and its corresponding pair of food trays for the remainder of the experiment.

Each test session consisted of two blocks of 20 trials (total $N = 40$). All subjects were given a minimum of nine training sessions. The placement of the food was block-randomized so that each position was baited an approximately equal number of times in the first and last half of each block of trials. No position was baited more than two consecutive times.

Phase 2: role training

In the second phase of the experiment, the apparatus was slightly modified by placing opaque shields in all food trays which prevented individuals

on the operator side from seeing whether the trays contained food, but which were clearly visible from the informant side. The rhesus monkeys were randomly divided by age into two groups and assigned to two different roles: informants (Tuck and Stud), and operators (Sundari and Fuzzy). Each monkey informant was paired with a human experimenter who assumed the role of operator, thus creating two separate dyads of a monkey informant and a human operator. The two monkey operators were similarly paired with this experimenter, who assumed the role of informant. Thus, we formed a total of four monkey-human dyads. All sessions from this point forward consisted of 20 trials and only one session was conducted each day.

Informants. For the monkeys who were designated as informants (Tuck and Stud), we began role training by positioning the apparatus so that the handles were facing towards the human operator and away from the monkey informants. Each trial began as a second experimenter placed a black hood over the food trays, preventing the human operator, but not the monkey informant, from seeing where the food was hidden. The subjects then watched as the second experimenter placed food into one of the dishes. During baiting, the human operator faced away from the apparatus and covered his ears with his hands to prevent him from potentially receiving 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 then removed the hood. The human operator waited for some manual gesture from the monkey informant as to the possible location of the food, and then made a choice of which handle to pull, based on cues (described later) provided by the monkey informant.

When the human operator pulled a handle, he removed the shield in the corresponding cup when it came within reach to determine whether it contained food. If it did, he removed the food and conspicuously consumed it while the subject retrieved the food from the other tray. If the human operator made an incorrect choice, he placed the shield back in the cup and a new trial began. All gestural behaviour by the monkey informants was spontaneous, although if the informants made no obvious gestures within about 15 s, the operator vocally asked the subject to show him the location of the reward. If the subject made no gestural response after 30 s,

the human operator made a choice based upon the subject's body movements or visual orientation. The monkey informants were scored as correct if the operator made a correct choice, and incorrect if he did not. The subjects were trained to provide gestures until the human operator was correct on 90% (or more) of the trials in two consecutive sessions, with the stipulation that each subject receive at least eight sessions.

Initially, we allowed the human operator to respond to a wide range of cues from the monkeys, including any visual orientation or physical gesture. We later instructed the human operator to become more selective in choosing the gestures to which he would respond. Thus, the subjects were gradually trained to produce a reaching/pulling gesture in front of the correct food tray. For purposes of consistency with previous research, this class of behaviour will be referred to as 'pointing' for the present. For Stud, we scored the types of cues that the human operator responded to on each trial. The categories were 'point', 'glance', and 'hand motion'. Point was scored on trials where Stud either (1) reached out of the cage in an attempt to grab the food, or (2) fully extended his arm out of the cage and placed his fingers on the surface of the apparatus or hooked his fingers inside one of the slots. Hand motion was scored if the experimenter responded to a movement of the monkey's hand or arm that was only partially, or not fully extended outside the cage. A typical example of hand motion was a waving of the hand, similar to that of an interrupted reach. Glance was scored on trials in which the human operator witnessed no obvious movements or gestures from the subject and therefore relied on the subject's visual orientation alone.

Operators. For the monkeys that were designated as operators (Sundari and Fuzzy) it was necessary to conduct an intermediate 'pointing comprehension phase' before we began the role training phase. In this intermediate phase we trained the subjects to respond to pointing cues given by a human informant in a series of steps. In the first step, we trained the subjects to respond to a human who held his hand above the correct tray. This will be referred to as 'cued' training. The apparatus was positioned so that the handles faced the monkey operator and the opaque shields were positioned in the trays to prevent the monkey, but not the human, from seeing which trays contained the food. At the start of each trial, a hood was

Table II. Design and results of pointing comprehension phase

| Subject | Sessions | Number of sessions | | % Correct* |
|---------|----------|--------------------|-----------|------------|
| | | Cued | Food-cued | |
| Fuzzy | 1-7 | 140 | — | 33 |
| | 8-20 | — | 260 | 58 |
| | 21-27 | 140 | — | 44 |
| | 28-42 | — | 300 | 70 |
| | 43-50 | 160 | — | 71 |
| Sundari | 1-7 | 140 | — | 38 |
| | 8-20 | — | 260 | 60 |
| | 21-27 | 140 | — | 53 |
| | 28-50 | 460 | — | 70 |

*Chance = 33%.

placed over the food trays, preventing the subject from seeing them. The human informant then showed the monkey a food reward, hid the reward behind one of the shields, and then pointed to the correct shield. The informant modelled his pointing after the reaching behaviour exhibited by Tuck and Stud, but positioned his fingers directly over the cup in order to make the gesture as visible as possible. A second experimenter then removed the hood and the animal was allowed to respond. Both subjects were given seven sessions using these procedures.

Because both animals consistently performed at chance levels, a second step was undertaken to assist them in orienting to the pointing. The procedure was identical to cued training except that the experimenter held a food reward in his fingers over the correct cup instead of merely pointing. This will be referred to as 'food-cued' training. The subjects were given 13 sessions each with this procedure, during which we gradually reduced the number of food-cued trials. By the 13th session the subjects were only food-cued once every fifth trial. We then returned the subjects to normal cued training. Because of variable performance by both subjects, we were forced to alternate this basic training strategy until each subject finally responded reliably on cued trials (see Table II for a summary of the design per subject). Each subject was given a total of 50 training sessions in this intermediate pointing comprehension phase.

We began the formal role training phase for Sundari and Fuzzy by placing the opaque shields in the trays on the informant side of the apparatus as

well as on the operator side. The procedure was identical to the cued pointing-comprehension phase, except that food was placed in both the monkey operator's food tray and the human informant's tray, thus establishing the cooperative task. If the monkey pulled the correct handle and displaced the shield, the human informant retrieved and ate his food reward as conspicuously as possible. If the monkey operator pulled a wrong handle, and displaced the corresponding cup, the trial was ended and the operator was scored as incorrect. The subjects were trained until they responded correctly on 90% (or more) of the trials during two consecutive sessions of testing, with the stipulation that each subject receive a minimum of 10 training sessions.

Phase 3: role reversal

At the beginning of the test session immediately following the final session of phase 2, we set up the apparatus as usual for each dyad. Then, as the animals watched, the apparatus was rotated, thus reversing the roles in each monkey-human dyad. The animals that had been trained as informants, therefore, were now tested as operators and those initially trained as operators were now tested as informants. For each subject, we looked for evidence of transfer into their new role during their first session of testing. For Tuck and Stud, the procedures were the same as those used with Sundari and Fuzzy in the formal role training portion of phase 2. For Sundari and Fuzzy, on the other hand, the procedures were the same as those used with Stud and Tuck in phase 2, except that the human operator responded selectively to gestures which met our criteria for pointing.

After the conclusion of phase 3, Tuck and Stud were trained using the pointing comprehension procedures (described earlier) until they responded for 2 consecutive days at 90% correct or better.

Control trials

To assess whether the subjects were relying on cues other than pointing, a control session was conducted with one of the subjects (Tuck) in which the human informant simply stood behind the apparatus and looked at the correct cup, without pointing. Twenty trials were administered. Tuck was also tested to determine how physical proximity might affect his responses. He was therefore

given two sessions ($N = 40$ trials) in which the experimenter moved his face to within a few centimetres of the correct cup.

The subjects were typically tested 5 days a week between 1100 and 1400 hours.

RESULTS

Phase 1: Retrieval Training

All subjects gradually learned to pull the correct handle when the food was directly visible over the course of 400 trials for Tuck, Stud and Sundari, and 440 trials for Fuzzy (Fig. 1a, d; Fig. 2a, d). Because Tuck and Stud received more pretraining trials than Sundari and Fuzzy, this may explain why their initial performance tended to be better. Tuck (the first subject we tested) showed a plateau of learning at around 60% correct during the first seven sessions (Fig. 1d). After we removed the fourth pair of food trays his performance improved dramatically in the final two test sessions until he was performing at 90% correct.

Phase 2: Role Training

Informants

During the initial sessions of testing, neither Tuck nor Stud displayed any behaviour that met our definition of pointing. However, their human partner (the operator) was able successfully to determine the location of the food based on cues other than pointing, such as the subjects' visual orientations (Fig. 1b, e). Using these cues, the human operator was able to find the rewards significantly more often than would be expected by chance alone (Table III). The human operator's performance (based on cues from each animal) gradually improved until the required criterion of a minimum of eight testing sessions was met (both subjects were producing accurate gestures on more than 90% of the trials during the final two sessions, Fig. 1b, e). Across these sessions, the human operator became more and more selective concerning the type of responses he would accept from the subjects. We adopted this procedure because the purpose of this phase was to train the monkeys to produce a manual gesture that would, by itself, unambiguously define the location of the reward. Figure 3 shows changes in the frequency of the human informant's use of various cues across the eight test sessions for the subject Stud. Because

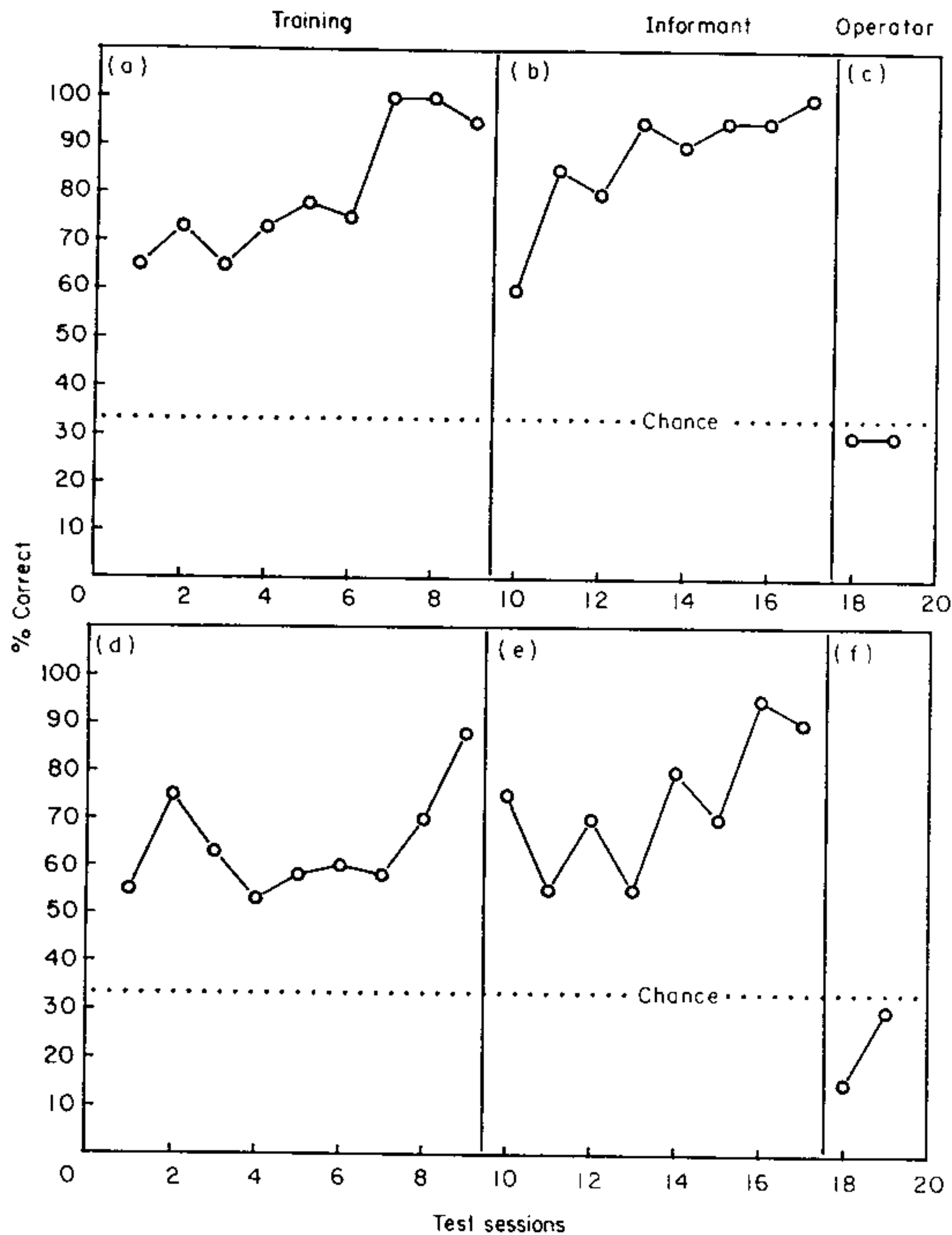


Figure 1. Performance of Stud (a-c) and Tuck (d-f) across all phases of the experiment. In training (a, d), the subjects visually located food on the apparatus and pulled a handle to retrieve it. As informants (b, e), the subjects were trained to reliably produce a 'pointing' gesture to a naive human operator. As operators (c, f), the subjects responded to the pointing gestures of a human informant.

the human operator always favoured a manual gesture (if the monkey produced one) over other cues, the results clearly revealed that pointing was not present initially but was gradually shaped by the experimental procedure (Fig. 3).

The pointing gesture of all of the subjects (including Fuzzy and Sundari in their role reversal phase) followed repeated attempts to pull the apparatus closer to them. The slots on the surface of the apparatus which guided the food trays appeared to offer the monkeys a convenient place to grab. Since they were often sitting in front of the correct food

tray while doing this, the behaviour was rewarded and eventually became highly stereotyped (Fig. 4).

Operators

Before Sundari and Fuzzy began formal role training, they were first taught to respond to pointing over the course of 50 sessions (see Methods). Initially, we tested them for seven sessions of pointing comprehension in which they responded to a human informant who pointed to the correct food tray. Both animals performed at chance levels during their first session (see Fig. 2b, f), and by the

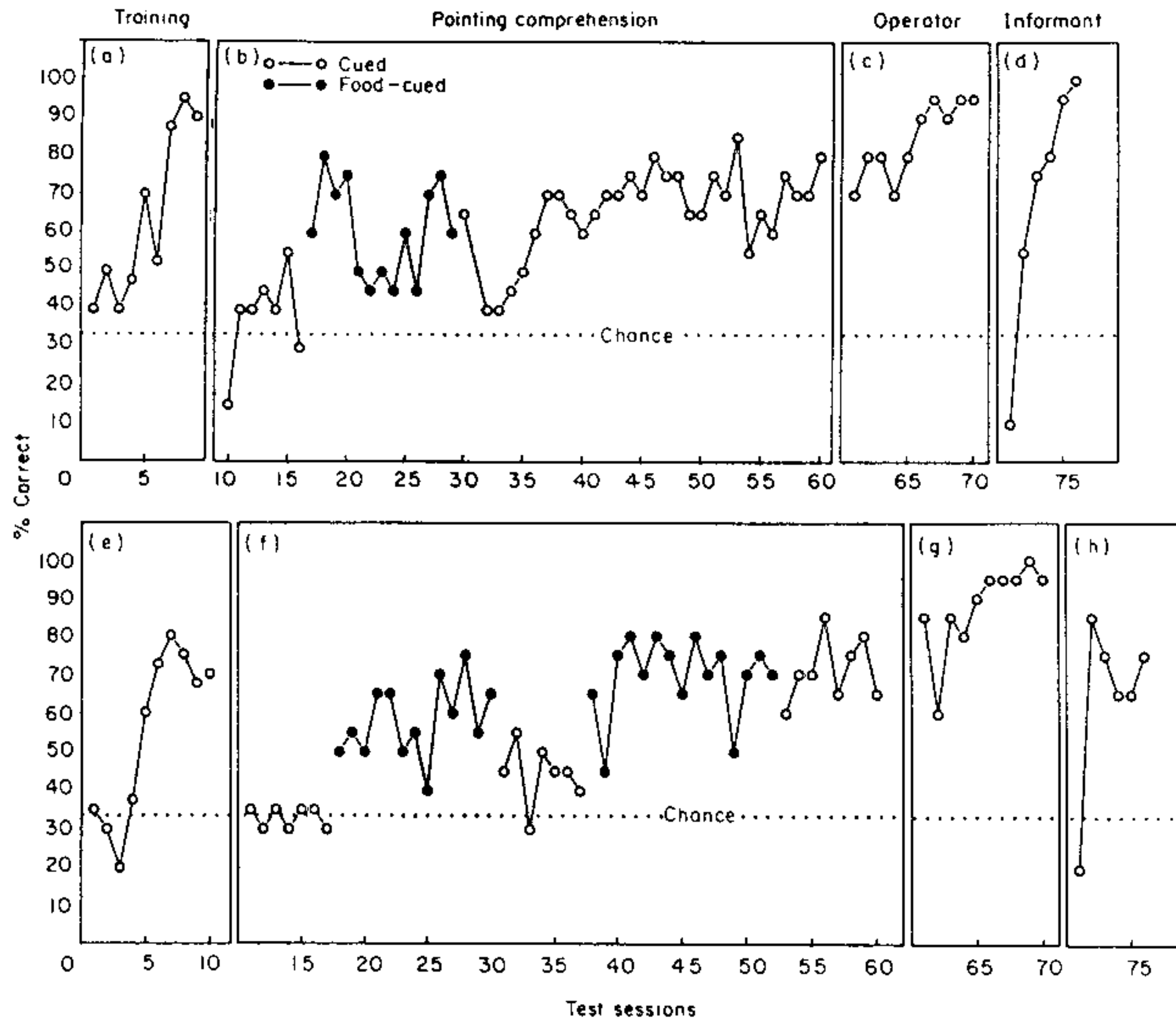


Figure 2. Performance of Sundari (a-d) and Fuzzy (e-h) across all phases of the experiment. In training (a, e), the subjects visually located food on the apparatus and pulled a handle to retrieve it. In pointing comprehension (b, f), the subjects were gradually trained to respond to a pointing gesture by a human. As operators (c, g), the subjects were trained to respond to pointing by a human informant, resulting in both the subject and informant obtaining food. As informants (d, h), the subjects were tested to determine whether they would immediately produce a 'pointing' gesture to a human operator.

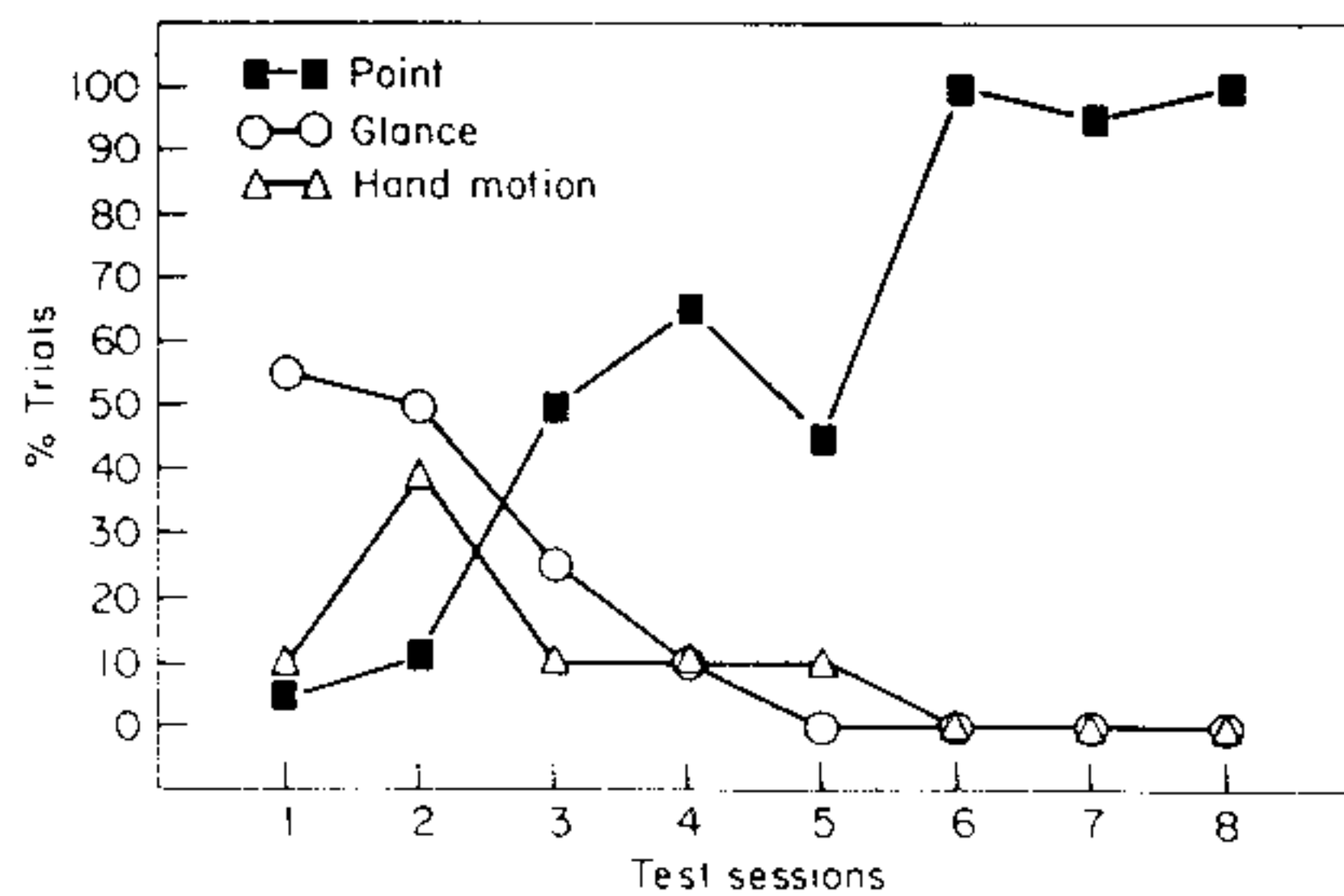


Figure 3. An analysis of the emergence of 'pointing' in Stud. Graph reveals the gradual development of the rewarded gesture (■) and the gradual decline of non-rewarded gestures (○, △).

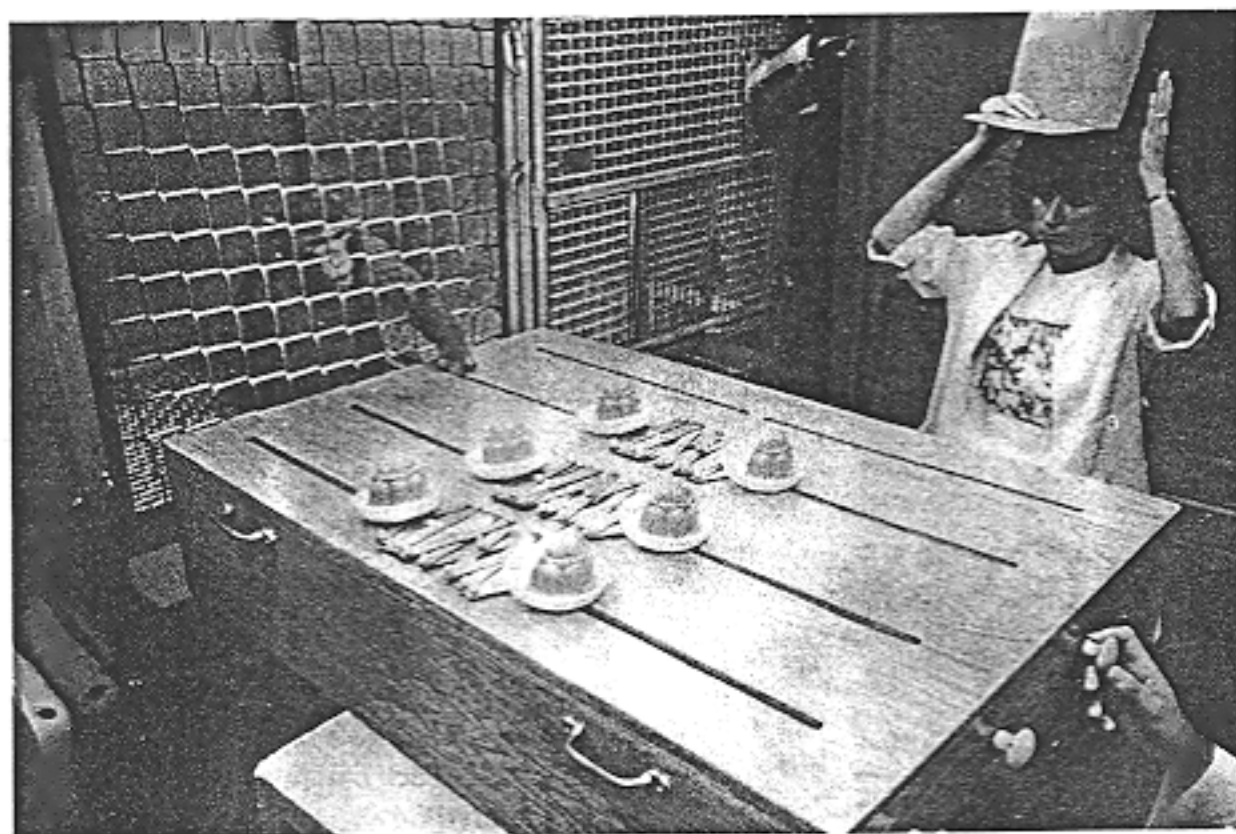


Figure 4. 'Pointing' gesture by a rhesus macaque informant to a naive human informant.

Table III. Results of day 1 of the role reversal phase 2 macaque informants in phase 2

| Subject | Number of trials | |
|-----------------------------------|------------------|-----------|
| | Correct | Incorrect |
| Tuck | | |
| First session as operator (11/20) | 15 | 5 |
| Expected* | 6.7 | 13.3 |
| Stud | | |
| First session as operator (11/20) | 10 | 7 |
| Expected* | 6.7 | 13.3 |

*Chance = 33%. The performance of each subject was evaluated using a chi-squared test, expected probabilities based on chance (Tuck: $\chi^2 = 9.02$, $df = 1$, $P < 0.01$, $N = 20$; Stud: $\chi^2 = 15.61$, $df = 1$, $P < 0.001$, $N = 20$).

end of the seventh session both animals were still responding randomly. We therefore introduced blocks of sessions using food-cued trials and alternated them with blocks of sessions using pointing alone until we trained the subjects to reliably respond to the pointing of the experimenter without food present (see Table II for a summary of these results).

Formal role training sessions immediately followed the pointing comprehension phase. Both animals showed very similar learning curves and both easily met the criterion of 90% (or more) correct responses for two consecutive sessions, and thus were trained for the minimum 10 required sessions (Fig. 2c, g).

Phase 3: Role Reversal

The critical results of the experiment can be seen by examining the subjects' transfer from the final session of role training into the first session of role reversal. Tuck and Stud's performance immediately dropped to chance levels when they became operators in phase 3 (see Fig. 1c, f and Table IV).

Sundari and Fuzzy showed an analogous and significant drop in performance from their last session as operators to their first day as informants ($P < 0.001$ for both subjects, Table IV). In repeated attempts to pull the apparatus forward and turn it around, Fuzzy quickly learned the correct response of pointing and showed a dramatic improvement in the second session of role reversal. In contrast, Sundari showed a gradual learning curve over the six sessions of role reversal.

In preparation for another experiment (see Povinelli et al. 1991) we subsequently trained

Table IV. Results of day 1 role reversal phase for all subjects

| Subject | Number of trials | |
|--|------------------|-----------|
| | Correct | Incorrect |
| Tuck | | |
| Last session as informant (role training) | 18 | 2 |
| First session as operator (role reversal) | 3 | 17 |
| Stud | | |
| Last session as informant (role training) | 20 | 0 |
| First session as operator (role reversal) | 6 | 14 |
| Fuzzy | | |
| Last session as operator (role training) | 19 | 1 |
| First session as informant (role reversal) | 4 | 16 |
| Sundari | | |
| Last session as operator (role training) | 19 | 1 |
| First session as informant (role reversal) | 2 | 18 |

Performances of each subject were compared using a chi-squared test corrected for continuity (Siegel 1956; Tuck: $\chi^2 = 18.57$, $df = 1$, $P = 0.001$, $N = 40$; Stud: $\chi^2 = 19.65$, $df = 1$, $P = 0.001$, $N = 40$; Fuzzy: $\chi^2 = 25.66$, $df = 1$, $P = 0.001$, $N = 40$; Sundari: $\chi^2 = 20.05$, $df = 1$, $P < 0.001$, $N = 40$).

Tuck and Stud to respond to pointing using the general methods described in the pointing comprehension phase of Sundari and Fuzzy. Tuck achieved criterion performance in 440 trials, whereas Stud reached criterion after 520 trials. These results underscore the general difficulty the subjects had in responding to pointing and the necessity of gradually shaping their attention to the gesture.

Control Sessions

In the first control session the experimenter merely stood behind the correct cup and passively stared at it without pointing. Tuck responded at chance levels (four out of 20 trials, where chance =

0.33, $\chi^2 = 1.60$, $df = 1$, $P > 0.05$, $N = 20$). This suggests that the monkeys were relying on the cue of pointing itself, and not other cues, such as the experimenter's gaze, in making their choice. In the second control test in which the experimenter moved his head to within close proximity of the correct cup, Tuck was correct on more trials than would be expected by chance alone (25 out of 40 correct, chance = 0.33, $\chi^2 = 15.75$, $df = 1$, $P < 0.001$, $N = 40$).

DISCUSSION

In contrast to previous results with chimpanzees, the rhesus macaques in this study showed little evidence for comprehension of their partner's social role. The two subjects that we first trained as informants (Tuck and Stud) displayed no signs that they understood the opposite social role when we tested them as operators. Their performances dropped from near perfect levels to chance levels when we reversed their roles. Similarly, Sundari and Fuzzy, who were initially trained to respond to pointing showed an analogous, impressive drop in performance on their first test session of role reversal. However, in contrast to Tuck and Stud, their performances did not remain at chance levels. Both subjects' performances improved quickly, especially Fuzzy's, and this might be taken as evidence that they did, in fact, understand the new role, but were distracted by the sudden change of routine on the first day of role reversal.

However, an examination of the videotapes of both subjects on their first days of role reversal provided little support for this hypothesis. Both subjects carefully watched the apparatus being rotated and remained alert and attentive throughout the test session. In fact, they appeared to be waiting for something to happen, often glancing at the experimenter. Instead, the videotape analysis provided support for the hypothesis that their improvement on subsequent days was the result of shaping. Fuzzy appeared to have discovered the correct response in his unsuccessful attempts to turn the apparatus around, presumably to gain access to the handles. In manipulating the apparatus, he produced one form of criterion response by having his fingers make contact with the top surface of the apparatus. Similarly, the emergence of Sundari's pointing behaviour was preceded by reaches toward the food which met the other

criterion for pointing. Thus, neither Sundari nor Fuzzy appeared to understand the task once their roles were reversed. This result can be contrasted with the results of the two chimpanzees that were trained in a similar manner by Povinelli et al. (1992). Neither of the subjects showed a significant decrease in their performance when their roles were reversed. They both produced unambiguous and accurate pointing gestures in their first session of role reversal.

One may wonder why Tuck and Stud appear to have performed better on their first session as informants in phase 2 than Sundari and Fuzzy did in response to the same procedures on their first day of role reversal. To view this comparison in its proper light, it must be remembered that our purpose in phase 2 for Tuck and Stud was to train them to point. As described previously, the human operator initially relied on small hand movements and glances by Tuck and Stud in determining a response. Figure 4 reveals that had we not accepted such cues, Stud's initial performance in phase 2 (and presumably Tuck's as well) would compare quite favourably to Sundari and Fuzzy's in phase 3. This procedural difference may also help to explain why Fuzzy's learning curve is so steep. Unlike Tuck and Stud, Fuzzy and Sundari were never rewarded for non-pointing behaviour, thus the reward contingency was more stable, perhaps leading to faster learning.

Our results can also be compared to those of Blaschke & Ettliger (1987) who reported on a study somewhat similar to the paradigm we used with Sundari and Fuzzy. Upon careful examination, Blaschke & Ettliger's results are fairly comparable to our own. First, it appears that their experimental subjects responded nearly at random for the first 20 trials after they were switched from pointing production, to pointing comprehension. Blaschke & Ettliger (1987) argue that the performance of their control group demonstrates that the four experimental monkeys in fact did comprehend pointing. However, those animals were taught a spatial alternation task while the experimental group was learning to respond to pointing. Thus, the control group may simply have been applying the alternation strategy when tested for pointing comprehension, thus artificially reducing their performance compared to the experimental group. Second, although their animals learned the task slightly faster than Fuzzy and Sundari, they also only had two choices. Third, their experiment did

not require the subjects to display a knowledge of a coordination of two distinct social roles on a cooperative task. Our monkeys learned to produce pointing, and eventually learned to comprehend pointing. What they did not appear to grasp was the intentional significance of their own gestures, or the gestures of their human counterparts. Finally, Blaschke & Ettliger could not rule out the possibility that their monkeys were responding to the bodily position of the experimenter, as opposed to the pointing itself. This suggests that their monkeys may have relied on only two widely separated cues. The potential importance of this problem can be seen in our second set of control trials with Tuck, as he proved quite able to respond to the correct cup when the body of the experimenter was in close proximity of the correct cup. However, the results of the first control test demonstrate that this was not a confounding factor in our procedure because the human experimenter generally stood in the same location when pointing.

It is clear from the results of the pointing comprehension phase for Fuzzy and Sundari, and the analogous training phase that Tuck and Stud received later, that responding to human pointing was a more difficult task for the monkeys than learning to produce a manual gesture in front of the appropriate food tray. We believe that this may be because human pointing holds no unique control over the macaque's behaviour. In other words, for rhesus monkeys 'pointing' is merely an environmental event that may or may not be associated with other events. In contrast, at some point in their development, young children (and probably young chimpanzees) come to understand pointing-like gestures as an observable behaviour which represents an unobservable intention (see Povinelli 1991 for a discussion). Therefore, the differential difficulty of the two roles explored in this study probably represent the difference between shaping a simple instrumental response in a subject ('pointing') versus a more complicated learning problem (i.e. 'select the handle that corresponds to the food tray under the experimenter's hand'). One interesting implication of this argument is that the word 'pointing' may be an anthropomorphic term when applied to rhesus macaques, but perhaps not when applied to similar behaviour by chimpanzees.

This experiment was conducted as part of a broader effort to subject Gallup's (1982, 1985) model of the distribution of attribution in non-human primates to a rigorous, empirical test. In

this context, the potential importance of our results can only be understood in contrast to the results of a companion investigation that used chimpanzees as subjects (Povinelli et al. 1992). In that experiment, three of four chimpanzees tested showed unambiguous evidence of transfer upon role reversal. This species difference is consistent with Gallup's hypothesis that chimpanzees, but not rhesus monkeys, ought to show evidence of empathy. Collectively, these results add to the experimental database which now suggests that chimpanzees may reason about mental states in other organisms, and to the growing absence of similar findings in monkeys. This emerging pattern highlights the potential predictive value of Gallup's model.

However, future investigations must consider the limitations of this research from two directions. First, the experimental evidence that chimpanzees attribute mental states to others still remains relatively weak. For example, this task appears to be a measure of simple forms of cognitive empathy, and therefore appears to argue in favour of the empathic abilities of chimpanzees. However, only comparative experiments with young children can provide compelling evidence to accept this interpretation (Povinelli & deBlois 1992, in press). Second, this experiment is only one measure of social attribution. Future attempts to falsify Gallup's model may wish to test macaques for attributional capacities that develop in children between 18 and 24 months of age. This is a critical age, for it represents the time period in which most children show the first signs of self-recognition (and hence, according to Gallup and others, self-awareness; see Lewis & Brooks-Gunn 1979). Thus, if rhesus monkeys showed evidence for these early forms of social attribution, but continued to show no evidence of self-recognition, Gallup's model would be in jeopardy. Such an outcome would demonstrate that reasoning about mental states in others need not depend on the type of self-awareness revealed by self-recognition in mirrors. For the present, however, such research remains in its infancy, and it thus remains unclear to what extent organisms both inside and outside the great ape-human clade conceive of mental states as causative agents of behaviour.

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