

## Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees

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Using their previously demonstrated gaze-following abilities, juvenile chimpanzees (and 3-year-old human children) were tested to determine if they interpreted seeing as the mental state of attention. The studies tested predictions generated by a low-level model of chimpanzee gaze-following which assumes that chimpanzees do not understand attention as an unobservable, internal mental state, and a high-level model which assumes that they do. In Expts 1 and 2, chimpanzees were first trained to respond to a cup to which an experimenter pointed, and then tested on probe trials to determine if they could respond correctly when the experimenter either oriented his or her whole head toward the correct cup, or just looked with the eyes. In Expt 1 these cues were static, whereas in Expt 2 the experimenter actively moved his or her head and/or eyes back-and-forth from the subjects' faces to the correct cup as they were attempting to make their choice. Expt 3 validated the logic of Expts 1 and 2 by demonstrating that 3-year-old human children responded in a manner predicted by the high-level model. The results of the experiments converged on supporting the predictions of the low-level model of juvenile chimpanzees' understanding of seeing.

Are humans profoundly different from other animals in how they understand the behaviour of themselves and others? In cultures around the world adult humans interpret behaviour in terms of underlying, unobservable mental phenomena (Avis & Harris, 1991; Lillard, 1998; Povinelli & Godfrey, 1993; Vinden, 1996). This attitude, or 'intentional stance' as Dennett (1983) has aptly named it, is not merely deployed in our interactions with our fellow humans. Although there are some limits, humans are predisposed to interpret a vast array of stimuli (including animals and inanimate objects) in a mentalistic manner—especially those that appear to move under their own volition (Heider & Simmel, 1944; Premack, 1990). Premack & Woodruff (1978) coined the term 'theory of mind' to refer to this human tendency to interpret behaviour in terms of unobservable

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mental states such as desires, intentions and beliefs. Since then, developmental psychologists have made a major empirical and theoretical effort to characterize the ontogenetic sequence of events leading to the emergence of the human ability to reason about emotions, attention, goals, desires, knowledge, and belief (Astington & Gopnik, 1991; Astington, Harris & Olson, 1988; Baldwin, 1991; Baldwin & Moses, 1994; Baron-Cohen, 1991, 1995; Bartsch & Wellman, 1995; Chandler, Fritz & Hala, 1989; Flavell, 1988; Frye & Moore, 1991; Harris, 1989, 1991; Leslie, 1987; Lillard, 1993; Meltzoff, 1995; Perner, 1991; Wellman, 1990; Wimmer & Perner, 1983).

Determining whether humans are alone in possessing theory-of-mind abilities is important for several reasons. First, understanding the ultimate functions of this folk psychology requires a specification of its evolutionary history. For example, one long-standing tradition holds that the kinds of abilities circumscribed by the term 'theory of mind' are impossible without language (Bickerton, 1987; Burke, 1966; Harré & Secord, 1972; Langer, 1942; Schwartz, 1980; Wittgenstein, 1953). However, if theory of mind psychologies are widespread among primates (or other taxa), then explanations of their evolutionary origins that appeal to the emergence of language cannot be correct. Another explanation for the evolution of theory of mind abilities lies in the idea that sociality has driven the emergence of complicated kinds of social intelligence (such as deception), ultimately leading to the ability to reason about mental states (Baron-Cohen, 1995; Humphrey, 1976; Jolly, 1966; de Waal, 1982; Whiten & Byrne, 1988). However, in order to evaluate this hypothesis properly, it is necessary to know which living species possess which aspects of theory of mind. Yet at present, even in the case of chimpanzees, very little is known about their theory of mind abilities. Comprehensive reviews of the state of our knowledge about theory of mind in non-human primates are available elsewhere (Cheney & Seyfarth, 1990a; Heyes, 1993; Povinelli, 1993, 1996a; Tomasello & Call, 1994; Whiten, 1993).

The most experimentally well-investigated aspect of theory of mind in non-human primates has been their understanding of 'seeing.' Organisms can (and almost certainly do) process information about the eyes of others without having to reason about internal mental states at all, as in the case of the response of predators to eye spots on moths (for examples, see Argyle & Cook, 1976; Gallup, Nash & Ellison, 1971; Perrett *et al.*, 1990). In addition to processing information in this amentalist fashion, seeing can also be understood as a mental act or event. This can occur in at least two different ways. First, the act of seeing can be understood as the deployment of attention. That is, when we observe someone looking at something, the person and object may automatically be interpreted as being connected by a kind of psychological spotlight emanating from the person doing the looking (Baldwin & Moses, 1994). Put another way, when people look at things, they reference those things. In philosophy of mind terms, this referential attentional relation is described as the 'aboutness' aspect of seeing. This kind of understanding of seeing-as-attention has been demonstrated in children as young as about 2.5 years of age (Gopnik, Meltzoff & Esterly, 1995; Lempers, Flavell & Flavell, 1977; Povinelli & Eddy, 1996a). Indeed, there is even evidence that infants as young as 18 months of age understand attention in this way, although there is no evidence that they understand the particular role that the eyes play in deploying attention (Baldwin, 1991; Baldwin & Moses, 1994; Tomasello, 1988; Tomasello & Farrar, 1986).

Finally, an even more sophisticated appreciation of the mental aspects of visual

perception involves understanding the epistemological consequences of seeing. That is, not only does the act of seeing connect organism and object, the perceptual act of seeing brings new information into the mind, thus altering an organism's previous state of knowledge. So, from the perspective of a third party, one who has seen an object or event is envisioned as possessing special knowledge *vis-à-vis* someone who has not. This level of understanding visual perception may not be firmly in place in young children until about 4 years of age (Flavell, Everett, Croft & Flavell, 1981; Flavell, Shipstead & Croft, 1978; Gopnik & Graf, 1988; O'Neill & Gopnik, 1991; Pillow, 1989; Povinelli & deBlois, 1992; Pratt & Bryant, 1990; Ruffman & Olson, 1989; Wimmer, Hogrefe & Perner, 1988).

Both macaques and chimpanzees have been investigated for their understanding of both of these aspects of seeing (Cheney & Seyfarth, 1990*b*; Povinelli, Nelson & Boysen, 1990; Povinelli, Parks & Novak, 1991; Premack, 1988). Studies with macaques have thus far converged on suggesting that they do not appreciate the connection between seeing and knowing, or even the level-1 (attentional) aspect of seeing (Anderson, Sallaberry, & Barbier, 1995; Cheney & Seyfarth, 1990*b*; Kummer, Anzenberger & Hemelrijk, 1996; Povinelli *et al.* 1991; Povinelli, Parks & Novak, 1992). Although initial studies with chimpanzees provided some evidence that they might understand the connection between seeing and knowing (e.g. Premack, 1988; Povinelli *et al.*, 1990), they suffer from important methodological limitations (reviewed by Povinelli, 1994; Povinelli & Eddy, 1996*a*). Povinelli & Eddy (1996*a*) recently addressed some of these limitations in a series of 15 studies, with both chimpanzees and preschool children, which examined the even more basic understanding of seeing as the mental state of attention by determining if young chimpanzees would selectively approach and use a species-typical begging gesture to request food from an experimenter who could see them as opposed to one who could not. Although the chimpanzees easily learned rules which allowed them to succeed on such tests, there was no strong evidence that they understood even this attentional aspect of seeing.

Despite the largely negative evidence to date, there are reasons to be cautious about concluding that chimpanzees do not understand seeing as a mental event. First, in the Povinelli & Eddy (1996*a*) studies where the chimpanzees had to gesture in front of one of two humans (one who could see them, the other who could not), the distance and general orientation of the experimenters were intentionally held constant in order to focus on the question of whether the subjects understood the face or eyes in particular as an attentional mechanism. However, if chimpanzees possess a genuinely mentalistic understanding of attention, but it is one based on different behavioural indicators (such as proximity and/or orientation or movement of head), then the methodology may have at least partially masked this understanding.

A second reason for caution concerning these results is that chimpanzees have now been shown to display gaze-following abilities as sophisticated as those demonstrated by 18-month-old human infants. By this age, human infants will: (i) follow the gaze of an adult past a distracter object to the true target of the adult's gaze; (ii) follow an adult's gaze in response to eye movement alone; and (iii) follow an adult's gaze even if the target of that gaze is outside the infant's immediate visual field (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; Corkum & Moore, 1994; Scaife & Bruner, 1975). Likewise, chimpanzees have been shown to do both (ii) and (iii)—they have not yet been tested explicitly for (i)—as well as to appreciate that line-of-sight is obstructed by opaque

barriers (Povinelli & Eddy, 1996a, b, 1997). Although it is possible that these gaze-following abilities may be supported by geometric or spatial representation mechanisms, and not representations of attentional states *per se*, it is also possible that in both ape and human infants alike these abilities signal an early, precocial understanding of attention (see Baron-Cohen, 1995).

Finally, the fact that the subjects in the Povinelli & Eddy (1996a) studies were always confronted with two experimenters simultaneously (one who could see the subject, the other who could not) may have hindered their ability to demonstrate an underlying understanding of attention. If chimpanzees have a slightly different theory of attention than our own, it might be easier to detect in situations where they need only reason about the attention state of one other organism, as opposed to simultaneously comparing the attentional states of two individuals.

The studies reported in this article sought to capitalize on the demonstrated gaze-following abilities of juvenile chimpanzees in order to determine if they would interpret the gaze of others as a cue to search in a particular location for a hidden reward. These studies pitted the predictions generated by two frameworks concerning chimpanzees' understanding of attention: a high-level, mentalistic framework which assumes that they, like us, understand attention as a mental state, and a lower-level framework which assumes that they do not. This low-level framework assumes that chimpanzees are extremely intelligent, social animals which are able to form impressive procedural rules for processing social information, and can use this information to anticipate ('predict') what other organisms are likely to do next. However, in contrast with the high-level model, this procedural rule framework assumes that chimpanzees do not conceptualize their understanding of the behaviour of others in terms of internal, unobservable mental states such as attention, desire, knowledge and belief.

## EXPERIMENT 1

In this study we trained chimpanzees to use the pointing gesture of an experimenter to select a baited cup (in this situation, the experimenter's gaze direction was neutralized, see below). We then tested the subjects by sometimes eliminating the pointing gesture, and instead having his or her visual gaze directed either directly at one of the cups, or directly into a corner of the ceiling above one of the cups. If the subjects understood the attentional significance of visual perception, they ought to perform well on the trials where the experimenter was looking at the cup, but randomly on those where he or she was not. On the other hand, if they possess a non-mentalistic understanding of gaze there would be no necessary reason for them to initially select the cup at which the experimenter was glancing, or if they did so, they could be expected to select it on the above cup trials as well. These predictions are elaborated below (see Predictions). Povinelli, Parks & Novak (1992) and Anderson *et al.* (1995) had previously tested rhesus macaques and capuchin monkeys, respectively, to determine if they would search in a location where an experimenter was looking. Neither study provided evidence that either species would do so spontaneously, although the Anderson *et al.* (1995) study demonstrated that after hundreds of trials the capuchins could learn to do so.

## Method

### *Subjects*

The subjects were seven 6-year-old chimpanzees (age range 6 years 0 months to 6 years 10 months). Six of the subjects were female and one was male. All were born in captivity at the University of Southwestern Louisiana New Iberia Research Center. Five of the subjects (Kara, Jadine, Mindy, Brandy, Candy) were raised together by human caretakers from birth in nursery setting with several other peers. The remaining subjects (Apollo, Megan) had been raised by their mother for approximately one year before being transferred to the nursery to be raised with the other five. A detailed description of the subjects' rearing histories is provided in Povinelli & Eddy (1996a). The subjects lived in a large complex of five indoor-outdoor housing units that were interconnected by passageways that could be closed off as necessary (floorplan dimensions =  $8.3 \times 12.6$  m; outdoor and indoor caging height = 3.3 and 2.1 m, respectively). These living areas contained ropes, swinging barrels, hard plastic toys, and wooden perches at various heights. The animals had free access to the entire area (except an indoor testing lab) at all times other than during testing periods. The animals were fed a standard diet of monkey chow, fruits and vegetables, and this was supplemented by fruits and vanilla wafer cookies which they received during testing.

Both before and during the experiments reported in this article, the subjects participated in a number of cognitive studies involving their ability to recognize themselves in mirrors and on video, to understand the connection between seeing and knowing, their ability to understand seeing-as-attention, to discriminate between accidental and intentional actions, to engage in various forms of gaze-following, as well as other studies involving matching-to-sample, spatial memory, and self-knowledge assessment (see Povinelli & Eddy, 1996a). The subjects had received extensive contact with human beings during their early rearing, and especially so during the preceding 4 years as part of a long-term project dedicated to assess their social understanding. Humans who had extensive daily experiences with the subjects over a periods of many months and, in most cases, a year or more, served as the experimenters in the studies reported here.

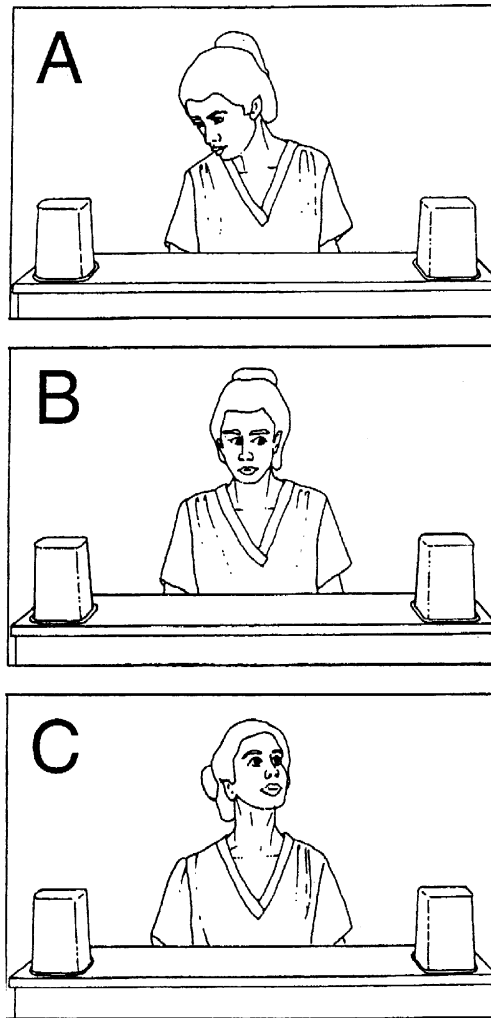
### *Apparatus*

A simple apparatus was constructed which consisted of a flat table ( $60 \times 120$  cm) with two upside-down opaque cups which were attached to the surface and separated by a distance of 70 cm (Fig. 1). The cups were attached with hinges so that they could be pushed over from the front revealing whether a food reward was hidden underneath.

### *Procedure*

*General setting.* Each subject was typically trained or tested individually once or twice a day. The subjects were trained and tested in a standard order and were thoroughly familiar with the transferring procedure. Before each training or test session, a subject was transferred out of the social group by opening the shuttle door which connected the main colony areas to a waiting area outside an indoor testing unit. Another shuttle door provided a passageway between the outdoor waiting area and an indoor testing room. As the subject passed through the shuttle door, it entered a test unit that was separated from the rest of the room by a plexiglas partition. This partition prevented the chimpanzees from entering the portion of the room where experimenters were situated. The partition contained several holes cut at a level convenient for the subjects to reach through. The shuttle door that connected the outdoor waiting area and the indoor test unit was controlled by the subjects' trainer using a remote pulley system located on the back wall of the testing room. When this shuttle door was closed, the subject was restrained to the outdoor area and could not see into the test unit. When the door was opened, the chimpanzee could enter the test unit and respond. In the current study, the apparatus described above was placed 10 cm from the partition, with the two cups lined up in front of the extreme left and right holes.

*Training.* In the training sessions the animals learned to turn over the cup to which an experimenter pointed and retrieve a food reward hidden underneath (through differential reinforcement they learned



**Figure 1.** Experimental apparatus used in Expts 1–3 and stimulus configuration of experimental treatments used: (A) at target, (B) eyes only, (C) above target.

that only one cup was baited on each trial). Several years earlier, five of the seven subjects (Megan, Brandy, Mindy, Apollo, Kara) had been trained to use the pointing of an experimenter to select one of three baited cups on a similar apparatus as part of an unrelated study. (These five subjects had been trained in sessions of nine trials to a criterion of 17 out of 18 consecutive correct responses. The subjects averaged 133.2 trials ( $SD = 94.5$ ) to meet this criterion.) The two remaining subjects (Candy, Jadine) had not received this previous training. On all pointing trials in the experiments reported in this article (as well the previous training that some of the animals received) the experimenter's gaze was fixed on a small target midway between the two cups.

Training was divided into three phases. In Phase 1, each subject was administered 10 trials per session. At the beginning of each trial, the subject remained in the outdoor waiting area with the shuttle door into the test room closed. Inside the test room, an experimenter turned over both cups, hid a food reward under one of them, and then returned both to their upright position. In each session of 10 trials, both the left and

right position were baited equally often; within that constraint, the location on each trial was randomly determined. The experimenter sat on a crate directly behind the apparatus with his or her body centered on a point midway between the two cups and fixed his or her gaze on a small target located at that point. When the experimenter was in position and ready, he or she indicated so, and the trainer used the remote pulley system to open the shuttle door. This action allowed the subject to enter the test unit at her or his leisure. After opening the door, the trainer remained facing the wall to minimize the subject's interest in his presence. The subject was allowed approximately 60 seconds to enter the unit. If the subject did not do so, the trainer lowered the shuttle door and the trial was re-executed after a delay of 30–60 seconds. As soon as the experimenter judged (using peripheral vision) that the subject's body had crossed the threshold of the shuttle doorway, he or she pointed to the baited cup, while maintaining the same posture described above. The first cup the subject touched was defined as the subject's choice (this criterion was used throughout the experiment). If the choice was correct, the experimenter praised the subject, the subject retrieved the food reward and then exited the test unit. If the choice was incorrect, the experimenter typically said, 'No, that's not right, [subject's name],' and the subject was not allowed to make a second choice. In some cases it was necessary to pull the apparatus back slightly to prevent a subject from making a second choice. All subjects were tested until they averaged 95% correct across two consecutive sessions. As they reached this criterion, each subject advanced to Phase 2.

Phase 2 of training was identical to Phase 1, except that the experimenter initiated the pointing gesture before the trainer opened the shuttle door, and maintained this posture until the subject had entered the test unit and made a choice. Thus, the experimenter was already pointing when the subject entered the test unit from the outside waiting area. The purpose of this phase was because during testing the experimenter would already be pointing (or, on probe trials, looking) when the shuttle door opened. Thus, to eliminate any differences between the pointing trials during training and testing, we implemented this phase. In order to thoroughly familiarize the subjects with this change, each subject received a minimum of four sessions, and a criterion of 95% correct across two consecutive sessions was required to advance to Phase 3.

Phase 3 of training consisted of a single session of trials which were identical to those in Phase 2, except that the experimenter sat on the floor behind the apparatus instead of on a crate. This change was implemented in order to configure the experimenter's eyes at approximately the same height as the chimpanzees' eyes as they entered the test unit and responded. Also, in order to familiarize the subjects with the setting to be used in the tests, an additional video camera was positioned behind and over the experimenter's left shoulder. This camera was used in the test sessions to record details of where the chimpanzees' glanced before and after responding.

*Testing.* The animals were tested using a probe trial technique in which novel test treatments (see below) were administered by embedding them into a background of pointing trials. Each test session consisted of eight trials. Trials 1–2, 4–5 and 7–8 were identical to the Phase 3 training trials. For these trials, the correct location (left or right) was randomly determined, with the constraint that each position was correct equally often. Trials 3 and 6 served as the probe trial positions for delivering the experimental treatments. Three experimental treatments were used: at target, above target, and eyes only. The at target treatment consisted of the experimenter orienting his or her entire head and eye gaze toward the target cup, with his or her upper torso and rest of the body aligned along the midline of the apparatus as in standard pointing trials. The eyes only treatment consisted of the experimenter orienting his or her head and body exactly as on the pointing trials, but diverting his or her eye gaze toward the target cup. The above target treatment consisted of the experimenter orienting his or her head and body in the same fashion as on the at target trials, but looking above and behind the baited cup to a predetermined target on the back wall of the test unit. This treatment was constructed so that at the point where the experimenter's imaginary line-of-sight passed over the cups it was 0.5 m above the cup, and continued to the far wall at an angle of approximately 60° from horizontal. Figure 1 displays examples of each of the treatments.

On all probe trials, the experimenter fixed the position of her or his eyes and head according to the scheduled treatment for that trial before the shuttle door was opened and the animal entered the test unit. While the animal was waiting out of sight in the outside area, the orientation of the head and eyes was standardized within and across the three experimenters that participated in the study, and was monitored by an observer in a different room via a remote video camera trained on the experimenter's face and the apparatus. This observer monitored and communicated (via intercom) with the experimenter in order to

ensure that the experimenter's posture was correct. Once the experimental configuration was set, the trainer was instructed to open the shuttle door as usual, allowing the subject to enter and to respond. The opening of the shuttle door signalled the beginning of the trial and from this point forward no further communication occurred over the intercom. The experimenter maintained his or her posture until the subject responded by turning over one of the cups. The duration of this posture varied as a function of how long the subject took to respond. Generally, the subjects looked at the experimenter once the shuttle door opened, and then walked into the test unit and responded.

Each subject received eight trials of each of the three general treatments (four trials of each treatment where the baited cup was on the left, and four trials where the baited cup was on the right). This resulted in a total of 24 probe trials per subject. Because there were two probe trials per session (trials 3 and 6), this meant that each subject was tested for 12 sessions. For each subject, each of the 24 probe trials was randomly and exhaustively assigned to successive probe trial positions until the probe trial slots in all 12 sessions were filled.

*Predictions.* The mentalistic framework predicted that on probe trials when the experimenter looked at the cup (eyes only, at target) the subjects would choose that cup. In addition, and of equal importance, we reasoned that an organism which understands the attentional significance of gaze would interpret the above target probe trials as indicating that the experimenter was not attending to either cup, and would thus choose randomly. In contrast, the non-mentalistic framework predicted that the subjects would respond randomly in all treatments, or that they would respond to the target cup in the at target treatment and the above target treatment. Thus, the above target treatment was implemented as a control to determine if the subjects' potential success on the at target trials was not because they understood the attentional focus of the experimenter, but rather because they were drawn to the side of the apparatus to which the experimenter was generally oriented in order to establish full face-to-face contact.

*Data analysis.* The main data were summarized by calculating the per cent correct score for each animal for each of the three types of probe trials (at target, above target, eyes only). Thus, each subject was assigned a score for each treatment consisting of the per cent correct out of the eight probe trials: 0, 12.5, 25, etc., correct. Next, the subjects' scores in each treatment were averaged to produce a group mean. A statistical analysis of the data was conducted in two steps. First, a one-way repeated measures analysis of variance (ANOVA) was used to compare all subjects' average scores for each treatment to each other. A second analysis used one-sample *t*-tests to determine if as a group the subjects performed at levels exceeding that expected by chance (50%) in any of the three treatments.

Two observers were separately administered standardized written instructions which asked them to observe every probe trial and record on a standard form whether or not 'the subject looked above and behind them' as they entered the testing unit. For those trials on which the raters indicated that the subjects did glance above and behind themselves, the raters were also asked to record into which corner (left or right) the subjects glanced first. The purpose of these ratings was to provide an assessment of whether the subjects were paying attention to the experimenter's facial orientation. If they were, we predicted that they would display glances above and behind themselves selectively on the above target trials. One rater served as the main rater, and the other was used to assess inter-observer reliability.

## Results

### *Training*

*Phase 1.* The five subjects who had been previously trained to respond to pointing required an average of 6.6 sessions (66 trials, range 4–16 sessions) to reach criterion and advance to Phase 2. All five of these subjects were responding at above chance levels within their first four sessions. In contrast, the two naïve subjects were not responding above chance after four sessions and were therefore a decision was made to cue them in a manner resembling that which occurred during the training that the other animals had received several years earlier. This cuing involved actively tapping on the correct cup and



holding a food reward between the fingers over the correct cup, typically on every other trial. Candy received six sessions (10 trials per session) involving such cuing; Jadine received seven sessions. After these sessions involving cuing, the subjects continued testing using the Phase 1 procedure, and both met criterion with two sessions. Thus, these subjects (Candy and Jadine) required 12 and 13 sessions respectively in order to meet criterion. Thus, the number of sessions in which it took the subjects to advance through Phase 1 ranged from 4–16 sessions.

*Phases 2 and 3.* Five of the subjects (Candy, Brandy, Megan, Apollo, Kara) met the criterion for Phase 2 in the minimum of four sessions. The remaining two subjects (Jadine, Mindy) both required six sessions. All subjects scored 10 out of 10 correct in the single Phase 3 session they received.

### Testing

As described earlier, each test session consisted of two probe trials inserted into a background of six pointing trials. The pointing trials were intended to serve as a motivational control to ensure that poor performance on some or all of the treatments was not due to possible fluctuations in the subjects' motivation to participate in the experiment. Further, given that the main purpose of the study was to determine if the subjects could translate between the actions of the experimenter on the standard (pointing) trials and his or her actions on the treatment (glancing) trials, it was necessary to show that they succeeded at high rates on the standard pointing trials. As a group, the animals averaged 96% correct ( $SD = 5.3\%$ ) on background pointing trials, thus demonstrating a strong interest and motivation to select the correct cup in order to obtain a food reward, and an appropriate context in which to test for the apes' capacity to translate between pointing and glancing. Thus, the results of the standard pointing trials are not considered further.

The main hypothesis concerned the subjects' performances on the three different types of probe trials. The results for the group are depicted by treatment in Fig. 2, and the results by subject are presented in Table 1. A visual inspection of the graph indicates that the subjects performed well on the at target and above target trials, but poorly on the eyes only trials. A one-way repeated measures ANOVA revealed a strong overall effect,  $F(2,12) = 14.700$ ,  $p = .0006$ . *Post hoc* Tukey–Kramer Multiple Comparison Tests indicated that the group performed significantly better on at target and above target trials than on eyes only trials ( $p < .01$  in both cases), and that the at target and above target performances did not differ significantly from each other. One-sample *t*-tests (two-tailed, hypothetical mean = 50%) confirmed the visual impression from Fig. 2 that as a group the subjects' responded significantly above chance on the at target [ $t(6) = 4.596$ ,  $p = .004$ ] and above target [ $t(6) = 3.286$ ,  $p = .02$ ] probe trials, but that the group's performance did not differ from chance on the eyes only probe trials [ $t(6) = 2.121$ , n.s.].

Given that the subjects performed significantly above chance in two of the three treatments, we further examined the group's performance on a trial-by-trial basis. This analysis was conducted in order to determine if the subjects had performed correctly from Trial 1 forward, or if they had learned (through differential reinforcement) to respond

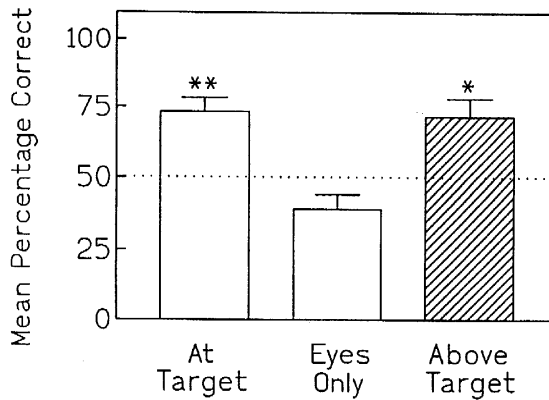


Figure 2. Mean percentage correct ( $\pm$  SEM) on probe trials by treatment for Expt 1. Dotted line indicates level of performance expected by chance responding. \*  $p < .05$ ; \*\*  $p < .01$ .

Table 1. Percentage of choices for target locations by individual chimpanzee subjects in Expt 1

Subject	Treatments		
	At target	Above target <sup>a</sup>	Eyes only
Candy	75.0	50.0	37.5
Jadine	87.5	100.0	50.0
Brandy	75.0	62.5	62.5
Megan	87.5	87.5	25.0
Mindy	62.5	75.0	25.0
Apollo	50.0	62.5	37.5
Kara	75.0	62.5	37.5
Mean	73.2	71.4	39.3

<sup>a</sup> Target location for the above target treatment refers to the target below the experimenter's line of sight.

correctly across the eight trials of each treatment that they received. This examination has significance in terms of the frameworks under evaluation. If the subjects displayed no evidence of selecting the correct cup during the initial at target trials, but gradually learned to do so, there would be no exclusive support for the mentalistic framework. On the other hand, an immediate understanding on the at target trials, coupled with a gradual learning curve on the above target trials would provide support for the idea that they interpreted the attentional focus of the experimenter correctly in both cases.

In order to examine these possible learning effects, we analysed the data in several steps. First, we examined each of the two relevant treatments (at target, above target) separately. Because there was a Trial 1, 2, 3, and 4 for both the left and right instances of each of the two treatments, we collapsed individual subjects' data for their first left and right instance

of each treatment to yield a per cent correct score for each of the four left/right pairs of trials. Thus, each animal received an average score of 0, 50 or 100% correct for the four sequential pairs of trials in the at target and above target conditions. Next, a group mean was calculated for each of these four pairs of trials in each of the two conditions. These results are plotted in Fig. 3. Two separate one-way repeated measures ANOVAs confirmed the visual impression from Fig. 3 by indicating no effect of trial pair for either treatment ( $p > .15$ , n.s., in both cases). Further evidence that the subjects did not show a learning effect across the probe trials was obtained after examining the group's average performance across the 24 probe trials in blocks of four trials in the actual order in which the subjects received them, irrespective of treatment. A one-way repeated measures ANOVA did not detect a significant effect of trial block ( $p = .60$ , n.s.). Thus, the subjects' above-chance performance in the at target and above target treatments did not appear to be the result of learning that occurred in the context of this experiment.

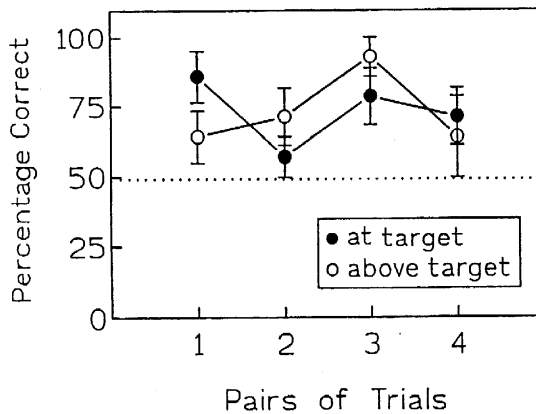
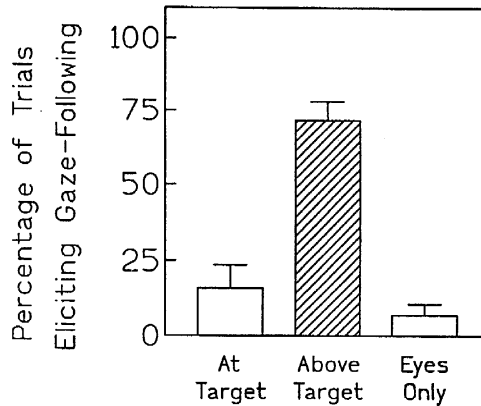


Figure 3. Mean percentage correct ( $\pm$  SEM) on successive pairs of probe trials for at target and above target treatments in Expt 1. Dotted line indicates level of performance expected by chance responding.

Finally, we examined the data from the raters who coded each probe trial for whether the subjects glanced above and behind themselves into the corners of the test unit (the locations where the experimenter glanced on the above target trials). Averaged first across the individual trials, then across animals, and finally across the three treatments, the raters agreed on 87% of the 168 probe trials they scored (at target = 87.5%; above target = 82.1%; eyes only = 91.1%). The results of the coding by the main rater are shown in Fig. 4, and indicate clearly that as measured by their tendency to follow the gaze of the experimenter on the above target trials, the subjects were attending very carefully to the facial orientation of the experimenter. A one-way repeated measures ANOVA confirmed the presence of an overall effect of treatment [ $F(2,12) = 39.120$ ,  $p < .0001$ ], and *post hoc* Tukey-Kramer tests indicated that, as predicted, the subjects glanced above and behind themselves significantly more in the above target treatment than in either of the other two treatments ( $p < .001$  in both cases), which in turn did not differ from each other. A further comparison of the main rater's data for the first side to which the chimpanzees glanced indicated that as a group, when they did glance, 82.2% of the time the subjects' first glance was to the same side that the experimenter had glanced. A one-sample *t*-test

(two-tailed) indicated that this agreement differed strongly from a hypothetical mean of 50% [the percentage agreement expected by chance;  $t(6) = 4.525, p = .004$ ]. Thus, the subjects not only noticed and followed the experimenter's distracted gaze in the above target treatment, but they also were highly selective about where they looked in response to this distracted gaze.



**Figure 4.** Mean percentage of trials eliciting gaze-following response ( $\pm$  SEM) in response to experimental treatments in Expt 1.

### Discussion

Consistent with the predictions of the mentalistic hypothesis, the subjects did reliably select the cup at which the experimenter was looking in the at target treatments. However, this result must be considered in relation to the results of the other treatments. The subjects performed randomly on the eyes only trials in which the experimenters looked at the correct cup. One possible interpretation of this finding is that the subjects have a theory of attention, but they do not understand the specific role that the eyes play in grounding attention (for discussion and data on this point, see Povinelli & Eddy, 1996a). However, the fact that the subjects performed as well on the above target trials as they did on the at target trials provides a serious challenge to this interpretation. The line of the experimenter's vision on these trials was clearly not intersecting the target cup (see Fig. 1). Indeed, on 71% of these trials, the subjects tracked the experimenter's gaze above and behind them, indicating that they were (at some level) processing the line-of-sight of the experimenter (for discussions of the meaning of gaze-following in human infants and other species, see Butterworth & Jarrett, 1991; Povinelli & Eddy, 1996b, 1997).

The finding that the chimpanzees did, in fact, select the cup underneath the experimenter's line-of-sight in the above target treatment is consistent with the prediction generated by the non-mentalistic framework that the subjects would orient themselves in front of the experimenter's face, after which they would simply choose the nearest cup. Thus, on both the at target and above target trials, regardless of where the experimenter was looking (at or above the target), the chimpanzees may have been drawn to that general location, and found themselves in front of the correct cup. In the eyes only treatment, we

intentionally eliminated this possibility by having the experimenter's head oriented to a point exactly midway between the two cups. In this case, if the apes were drawn to approach the experimenter's face, they would have found themselves equidistant from the two cups, and thus have chosen randomly. This is precisely the pattern of results we obtained.

## EXPERIMENT 2

The previous experiment used static cues for indicating the focus of an experimenter's attention. In human infants and young children, more active cues often accompany communicative exchanges between infant and adult. For example, infants often alternate glances between an adult's face and a desired object, as do the adults when attempting to draw infants' attention to particular objects or events. This kind of gaze alternation has been interpreted by some researchers as evidence that the infant and the adult are jointly aware of the locus of each other's attention. Thus, we devised more active versions of the treatments used in the previous study to signal the correct location to the apes in order to determine if this would improve their performance in the eyes only treatment. In addition, in the above target treatment, we wished to determine whether a clarification that the experimenter's attention was focused somewhere other than the apparatus might lead the chimpanzees to discount the experimenter's gaze as being relevant to the food location. (If the subjects' pattern of responses differed from that of the previous experiment, we planned to repeat that study in order to complete an ABA design. This would allow us to determine if any differences obtained were due to the treatments or simply to the repeated exposure to trials of this general type.)

## Method

### *Subjects and apparatus*

The subjects were the same seven chimpanzees used in the previous experiment. Each subject began participation in this study after completing the previous experiment. The average break between the studies was 10 days (range 1–18 days). The same apparatus was used.

### *Procedure*

*Orientation.* Each subject was administered a single orientation session which consisted of 10 trials that were identical to the Phase 3 training trials in the previous experiment. Thus, an experimenter sat on the floor behind the apparatus, baited a cup according to a randomized schedule (counterbalanced for side correct), fixed his or her gaze on the neutral spot between the two cups, and pointed to the baited cup. The trainer then opened the shuttle door, allowing the subject to enter and respond.

*Testing.* The three treatments used in the previous study were modified to provide more active cues for the subjects. For the at target trials, the experimenter focused on the subject's eyes/face as she or he entered the test unit through the shuttle door. As soon as the subject stepped into the test unit, the experimenter began glancing back and forth in rapid alternation from the subject's face (making direct eye contact when possible) to the correct cup. The experimenter continued this action until the subject responded by choosing one of the cups. The action was choreographed to make it appear as much as possible (from our human perspective) that the experimenter was attempting to signal non-verbally to the subject which was the correct cup. On the eyes only trials, the experimenter again watched the shuttle door and as soon the

subject crossed the threshold of the door, the experimenter moved his or her eyes back and forth from the subject's eyes/face to the correct cup. Finally, on the above target trials, the experimenter again started by orienting to the subject's face and then glanced (by moving the whole head) from the subject's eyes/face to target locations above and behind the baited cup (the same targets from Expt 1). The format of the testing procedure was otherwise identical with the previous study. New randomization and counterbalancing schedules were created within the constraints described in the previous experiment. Data summary and analysis also proceeded as in the previous study.

### Results and discussion

All subjects were correct on 100% (10 out of 10) of the standard pointing trials they received during their orientation session.

As in the previous experiment, each test session consisted of two probe trials inserted into a background of six pointing trials. The group was successful on 97.6% (SD = 4.2%) of all background pointing trials, thus indicating their strong interest and motivation to select the correct cup in order to obtain a food reward.

As in the previous study, the main hypothesis concerned the subjects' performances on the probe trials, and especially on the eyes only and above target trials. The subjects' mean performance by treatment is depicted in Fig. 5 and their individual performances are presented in Table 2. As in the previous study, the subjects performed well on the at target and above target trials, but poorly on the eyes only trials. A one-way repeated measures ANOVA failed to reveal a strong overall effect of treatment [ $F(2,12) = 2.223, p = .15$ ]. However, planned one-sample  $t$ -tests (two-tailed, hypothetical mean = 50%) confirmed the impression from Fig. 5 that the group responded significantly above chance on the at target [ $t(6) = 3.603, p = .011$ ] and above target [ $t(6) = 4.583, p = .004$ ] probe trials, but that they did not do so on the eyes only probe trials [ $t(6) = 0.781, n.s.$ ].

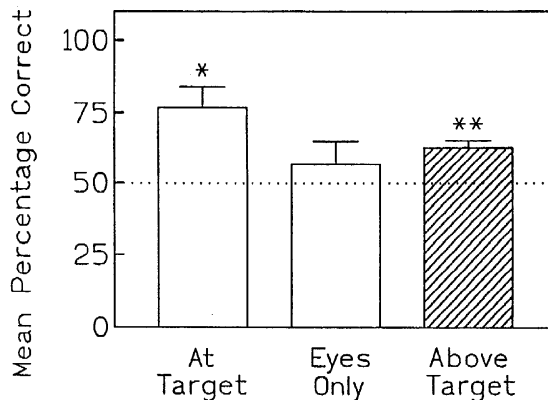


Figure 5. Mean percentage correct ( $\pm$  SEM) on probe trials by treatment for Expt 2. Dotted line indicates level of performance expected by chance responding. \*  $p < 0.5$ ; \*\*  $p < .01$ .

Given that the subjects performed at levels exceeding chance in the at target and above target treatments (as in the previous experiment), we again examined their trial-by-trial data in order to determine if they had performed correctly from Trial 1 forward, or if they

**Table 2.** Percentage of choices for target locations by individual chimpanzee subjects in Expt 2

Subject	Treatments		
	At target	Above target <sup>a</sup>	Eyes only
Candy	50.0	62.5	50.0
Jadine	87.5	62.5	37.5
Brandy	87.5	62.5	50.0
Megan	100.0	75.0	33.3
Mindy	50.0	62.5	50.0
Apollo	75.0	50.0	87.5
Kara	87.5	62.5	87.5
Mean	76.8	62.5	56.5

<sup>a</sup> Target location for the above target treatment refers to the target below the experimenter's line of sight.

had learned to respond correctly across the eight trials of each treatment that they received. The arrangement of the data proceeded as in the previous experiment, resulting in obtaining the group's mean per cent correct across the four pairs of left/right instances of each of the two treatments. These results are plotted in Fig. 6. Two separate one-way repeated measures ANOVAs indicated no effect of trial pair for either treatment ( $p > .42$ , n.s., in both cases). Additional evidence that the subjects did not learn their correct responses in the context of the experiment was obtained by examining the subjects' scores across the 24 probe trials (in blocks of four trials) in the actual order in which they received them, irrespective of treatment. As in the previous study, a one-way repeated measures ANOVA did not yield a significant effect of trial block ( $p = .83$ , n.s.). Thus, the subjects' above-chance performance in the at target and above target treatments was not the result of learning that occurred during in this experiment.

Finally, the data from the raters who coded probe trials for subjects' glances above and behind themselves was summarized and examined as in Expt 1. The raters agreed on the 89.3% of the 168 probe trials they scored (at target = 89.3%, above target = 83.9%, eyes only = 94.6% reliability). The results of the coding by the main rater are depicted in Fig. 7, and (as in Expt 1) indicate that the subjects were attending to the facial orientation of the experimenter. A one-way repeated measures ANOVA yielded an overall effect [ $F(2, 12) = 11.552, p < .002$ ], and *post hoc* Tukey-Kramer tests indicated that as expected the subjects glanced above and behind themselves significantly more during the above target probe trials than during either of the other two types of probe trials ( $p < .01$  in both cases), which in turn did not differ from each other. Furthermore, the main rater's data indicated that as a group, when the subjects did glance above and behind themselves on the above target trials, 70.5% of the time their first glance was to the same side that the experimenter had glanced. A one-sample *t*-test (two-tailed) indicated that this matching approached a significant departure from a hypothetical mean of 50% (the level of matching expected by chance),  $t(6) = 2.173, p = .073$ . Thus, as in Expt 1, the

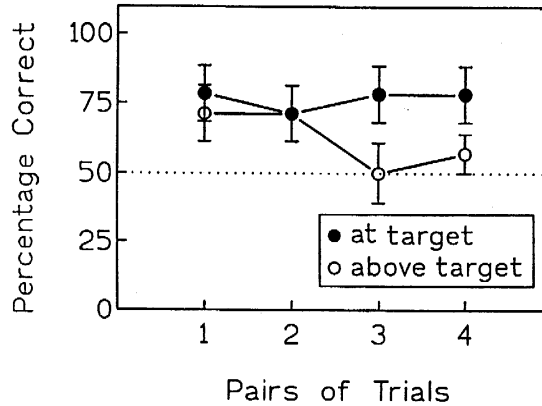


Figure 6. Mean percentage correct ( $\pm$  SEM) on successive pairs of probe trials for at target and above target treatments in Expt 2. Dotted line indicates level of performance expected by chance responding.

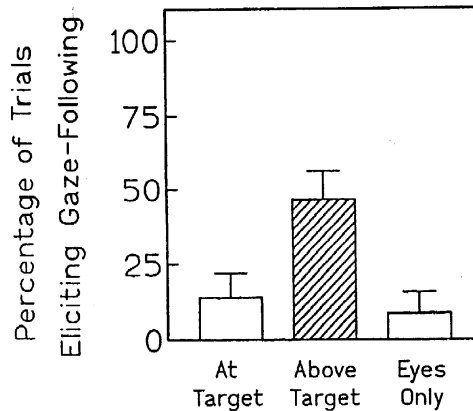


Figure 7. Mean percentage of trials eliciting gaze-following response ( $\pm$  SEM) in response to experimental treatments in Expt 2.

subjects noticed and followed the experimenter's distracted gaze in the above target treatment, and tended to be selective about where they looked in response to this distracted gaze.

### EXPERIMENT 3

In order to test the validity of our theory of the tasks administered to the chimpanzees in Expts 1 and 2, we administered the same test to 3-year-old human children. A substantial body of research indicates that 3-year-old children interpret the visual orientation of others in a mentalistic fashion. In particular, although 3-year-olds have difficulty understanding that the senses (such as visual perception) bring information into the mind, they have little difficulty understanding the attentional aspects of seeing (e.g. that the visual gaze of others connects them to the external world). Thus, they can easily



discern what another person is looking at, and can hide objects from view of others (Flavell, 1988; Flavell *et al.*, 1978, 1981; Lempers *et al.*, 1977). Thus, this experiment sought to validate the prediction of the high-level model that like the chimpanzees, 3-year-old children (who we have *a priori* reason to believe possess an understanding of attention as a mental state), ought to select the cup to which the experimenter is glancing in the at target (and possibly eyes only) treatment(s), but in direct contrast with the chimpanzees, select randomly in the above target treatment.

## Method

### *Participants*

The participants were 24 3-year-old children (age range 35–47 months, mean = 40.9 months, median = 40.5 months, 14 boys, 10 girls). The children were recruited from local preschools, information booths at civic functions, direct mailings, and flyers. The children's parents were contacted by telephone and were scheduled for a visit to a child testing facility at the University of Southwestern Louisiana. No systematic data were collected on the children's race or ethnicity, but they were primarily from working and middle class families residing in Lafayette, Louisiana and the surrounding communities.

### *Warm-up period*

Upon arrival, the parent and child were led into a warm-up area where they were introduced to the two experimenters who participated in the study. The main experimenter engaged the child in play while the second experimenter explained the testing procedures to the parent, showed him or her how the child could be observed through a one-way mirror during testing, and obtained his or her written informed consent. Once the child appeared comfortable with the experimenters and the surroundings they were invited into the adjacent testing room to 'play a game to find some stickers'.

### *Training procedure*

Upon entering the testing room, one of the experimenters helped the child prepare a piece of paper upon which they were to collect the stickers. The apparatus used in this study was of identical design and size as that used with the chimpanzees in Expts 1 and 2 (see Fig. 1). The apparatus sat on a table near the far wall of the room. In order to orient the child to the game, the main experimenter sat behind the apparatus (as in the chimpanzee studies), and showed the child how stickers could be hidden under the cups and then retrieved and placed on the paper. Once the child was familiar with turning over the cups, retrieving the stickers, and placing them on the page, the second experimenter invited the child to begin to play the game. The child was ushered to the wall that faced the apparatus and the main experimenter and was shown a chair in which they were to sit. The chair faced the wall so that the child was oriented 180° away from the main experimenter and the apparatus. Additionally, the second experimenter stood behind the chair and instructed the child not to turn around while the other experimenter 'hid the sticker'. While the child faced the wall, the main experimenter hid a sticker under either the left or right cup, then pointed to the correct cup while fixing her visual gaze on a point midway between the two cups as had been done with the chimpanzees. Once the main experimenter was ready, the second experimenter encouraged the child to 'go and find the sticker'. When the child stood up and turned around, he or she was approximately 2.5 m from the apparatus and the main experimenter. The child was allowed one choice (defined as moving one of the cups). If the child's choice was correct, they retrieved the sticker and placed it on the paper. If they were incorrect, the main experimenter revealed the sticker's location under the other cup and said, 'Ooops! Let's hide that and again and see if you can find it next time!' The subjects were administered five training trials, and were required to score at least four correct in order to advance to testing. To create each child's training schedule, the number of times the sticker was placed under each cup was approximately counterbalanced, and then exhaustively and randomly assigned for each child.

### Testing

The children were tested using the same three active versions of the treatments used with the chimpanzees in Expt 2: at target, above target, and eyes only. Each child was tested in two sessions, each of which consisted of six trials, with the two sessions separated by a brief interval in which the child was introduced to and allowed to play with a toy. The purpose of this was to maintain the children's interest in the task. In each session, three of the trials (1, 3, and 5) were identical to standard training trials. The remaining three trials (2, 4, and 6) were probe trials corresponding to each of the three treatments types. Thus, each child received two trials of each treatment type, allowing a score of 0, 1, or 2 correct for each treatment. Counterbalancing procedures were designed so that the correct side for that standard pointing trials occurred equally often on the left and right in both sessions, and so that one of the correct trials for each of the probe trial types occurred on the left and the other occurred on the right. An exhaustive design was used (with respect to the trial number placement and side correct of the treatments) so that 12 unique schedules were created, with two children assigned to each schedule.

### Results and discussion

The participants averaged 4.12 trials correct out of five during the training phase. One child was not tested because she did not reach criterion. She was replaced with another child of the same age.

In testing, each child received two trials of each treatment. Thus, for each treatment, if the children were responding randomly they could be expected to receive a score of 1. One sample *t*-tests (two-tailed, hypothetical mean = 1.00) revealed that like the chimpanzees, the children performed randomly on eyes only (mean = 1.00, SD = 0.511), but significantly above chance on at target (mean = 1.50, SD = 0.66,  $t(23) = 3.715$ ,  $p = .0011$ ). However, in direct contrast with the chimpanzees, and in clear support of the *a priori* prediction of the high-level model, the children responded randomly on the above target trials (mean = 0.96, SD = 0.69). A one-way repeated measures ANOVA indicated a significant overall effect [ $F(2,46) = 7.012$ ,  $p = .0022$ ], and a Tukey-Kramer Multiple Comparisons Test indicated that this effect was due to the fact that the children scored significantly higher on the at target trials than on both the eyes only and above target trials (both  $p$  values < .01), the latter of which did not differ from each other. Thus, consistent with the predictions of the high-level model, the children appeared to interpret the distracted gaze of the experimenter in the above target treatment as indicating that her attention was directed elsewhere, and hence not relevant to finding the correct location of the sticker. The children's difficulty with the eyes only treatment may reveal that for them (and possibly the chimpanzees as well) the eye movement was not salient enough to trigger the attribution of attentional focus or direction.

### GENERAL DISCUSSION

At least three methodological concerns must be addressed in order to interpret properly the results reported here. First, the chimpanzees had had considerable experience of participating in other cognitive studies prior to those reported here (see Subjects, Expt 1). Although the current studies are built on previous ones, it is possible to argue that this may have had a cumulatively negative effect on the ability to measure what the studies were intended to measure. We doubt this for several reasons. First, these studies were designed to make good (folk) psychological sense in terms of previous ones. Furthermore,

we suspect that if our apes had a folk psychological understanding of attention, then even if they did not originally understand what we were asking them, they should have uncovered the common denominator across these (and previous) experiences. We find it implausible to imagine that an organism with the kind of psychological understanding of attention for which we were probing would have performed cumulatively worse with increasing experience. Consider the children who participated in Expt 3. We find little reason to think that more experience with tests of this nature would obscure their ability to demonstrate their underlying appreciation of the mental state of attention. Second, the chimpanzees produced the behaviours that were being measured and which were of direct theoretical interest in terms of testing the alternative frameworks. For example, in Expts 1 and 2 the chimpanzees followed the experimenters' gaze and turned over cups even when the experimenters were not pointing. This demonstrates their ability to respond to the aspects of the task that set the appropriate context for testing them.

A second methodological issue concerns the logic of having the chimpanzees reason about humans. Elsewhere, we have addressed this issue in considerable detail and we direct the interested reader to this discussion (Povinelli, 1996*a*; Povinelli & Eddy, 1996*a*). Although we cannot review all of the issues here, we note that in the course of these and related studies, we have shown that the chimpanzees respond to the visual systems of humans in much the same fashion as they do to those of chimpanzees. For example, they scan our faces and follow our gaze, they take into account the opaqueness of objects that our gaze strikes, and they use their gestures to respond to our movements and postures in the same fashion as the same movements and postures of conspecifics (Povinelli & Eddy, 1996*a, b, c*, 1997; see Tomasello, Call, Nagell, Olguin & Carpenter, 1994). Thus, in addition to the fact that these apes were reared with and have developed strong attachments to those who work with them, we possess considerable empirical evidence that (on the surface at least) they respond to us in the same fashion as they would respond to other chimpanzees. Thus, in order to sustain the objection above, we would have to imagine that these subjects follow the gaze of both humans and other chimpanzees, but when it comes to interpreting that gaze in a mentalistic fashion they only do so when they are responding to conspecifics. Not only does this seem implausible, even if it were true it would already suggest a profound difference in the kind of system operating in the two species (see Povinelli, 1996*a*). After all, young children are perfectly willing to attribute mental states to a wide array of animate and even inanimate entities (Miller & Aloise, 1989; see Eddy, Gallup & Povinelli, 1993, for empirical data on the scope of mental state attributions by humans to other animals).

A third methodological issue concerns whether training the chimpanzees to respond to the pointing gesture might have interfered with their understanding of the later probe trials. In other words, by neutralizing the direction of the experimenter's gaze with respect to his or her pointing gesture, we may have unwittingly taught the subjects to discount the gaze direction of the experimenter as being relevant to the task (i.e. that this was not a task about attention). Although possible, we find this objection weak for several reasons. To begin, of course, there is the obvious empirical fact that far from causing the subjects to ignore our gaze direction, this manipulation appeared to have sensitized them to it. This is evident from the fact that not only did our subjects use our gaze direction to select the correct cup in the at target trials, they followed our distracted gaze on the above target probe trials at even higher levels than in some of our previous studies involving

these same subjects (see Povinelli & Eddy, 1996a, b). In addition, our results with human children cast doubt on this view. Admittedly, the children only received five training trials (because they met criterion very quickly), whereas the chimpanzees received 80 or more, but that is of direct interest in its own right. First, it indicates that the children understood the referential significance of the pointing gesture (something apes may not; see Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997). Second, the fact that the children received fewer pointing training trials was because they learned the initial structure of the task more rapidly. Thus, if the objection to our decision to neutralize the gaze cue has merit, the children should have also learned that the game was not about attention just as rapidly as they learned to exclusively rely on the pointing gesture. Finally, it is worth noting that had we allowed pointing and gaze direction to covary in training, the results of the probe trials would have been largely uninterpretable.

Although our results are most consistent with predictions generated by the low-level model, there are in fact at least three more specific possibilities. First, our current results can be interpreted as continuing to point to a dissociation in chimpanzees between their abilities to deploy very useful behaviours which take into account the gaze direction/postural orientation of others on the one hand, and their ability to interpret such postures and orientations as indicating attentional states *per se* on the other (see Povinelli & Eddy, 1996a). One interpretation of this possibility is that a theory of attention (and perhaps theory of mind more broadly) evolved only in the human lineage (e.g. Tomasello, Kruger & Ratner, 1993). It is possible that during the past 4–7 million years, the human lineage evolved cognitive specializations in theory of mind abilities that place us in the unique position of being able to reinterpret ancient behavioural patterns which we share in common with many social primates (e.g. gaze-following, deception) in explicitly mentalistic terms (e.g. Povinelli, 1996b; Povinelli & Prince, 1998). This is not to deny the causative role that reasoning about mental states plays in our behaviour. Rather, this idea highlights the fact that the possible roles that our understanding of mental states play in generating behaviour lie on a spectrum of possibilities, ranging from situations in which our behaviour is driven by hard-wired or tightly automatized processes to those that are the result of deliberate introspection and planning.

A second possible account of our data is that chimpanzees possess an interpretation of attention which is mentalistic, but based on different behavioural indices than that used by our own species. However, Brothers & Ring (1992) note that a distinction should be drawn between social stimuli that possess an emotional (hot) valence for organisms and more cognitive (cold) intentional-based interpretations of social action. For example, Povinelli & Eddy (1996c) reported that the same chimpanzees tested in the studies reported in this article displayed evidence of preferring an experimenter making direct eye contact with them as opposed to one who did not, as well as experimenters who engaged in subject-oriented species-typical head movements over other stimulus configurations. Although such data could indicate the operation of 'hot' aspects of theory of mind (as opposed to the recognition of the cognitive aspect of seeing-as-attention), they do not rule out the possibility that a high-level mechanism is, in fact, in place, and contributes to the attraction of chimpanzees to some attentional indices over others. Yet we are cautious of this latter point, precisely because in this investigation we attempted to focus on the question of attention broadly (not on the question of the role that the eyes play in the process of seeing). Thus, we typically manipulated gaze and posture

simultaneously to give the apes multiple redundant cues about the attentional state(s) of one or more experimenters.

Finally, our results (as well as the results of previous studies with young, juvenile, or adolescent chimpanzees) could be interpreted to mean that these particular chimpanzee subjects have not yet developed the purported theory-of-mind abilities of adult chimpanzees (see Povinelli & Eddy, 1996a, for a discussion). This is a real possibility given that the general developmental schedules of chimpanzees and humans do not appear temporally synchronous. In particular, some skills which emerge about 18–24 months in human infants, may not be deployed until 5 years or older in chimpanzees (see Povinelli, 1996a). However, it is important to keep in mind that these subjects are already three-quarters of their way to sexual adulthood and have yet to display an appreciation of attention which appears to be in place by 2½ years of age in humans. Furthermore, more recent tests with these same animals, using the Povinelli & Eddy (1996a) procedures, have shown that even at 8 to 9 years of age they still did not display evidence of understanding of seeing as attention (Reaux, Theall & Povinelli, in press). Nonetheless, even if it turns out that older chimpanzees do develop a deeper understanding of the mental state of attention than that demonstrated here, work of the kind reported here can continue to reveal the ways in which various cognitive processes and behavioural systems (e.g. gaze-following and an understanding of attention as a mental state) can be developmentally dissociated. The existence of such dissociations will ultimately provide important constraints on the kinds of arguments developmental psychologists can marshal about the causative role of specific behavioural-cognitive mechanisms in the ontogeny of theory of mind.

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