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ORIGINAL ARTICLE

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Chimpanzees' (*Pan troglodytes*) use of gaze cues in object-choice tasks: different methods yield different results

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Abstract To assess the influence of different procedures on chimpanzees' performance in object-choice tasks, five adult chimpanzees were tested using three experimenter-given cues to food location: gazing, glancing, and pointing. These cues were delivered to the subjects in an identical fashion but were deployed within the context of two distinct meta-procedures that have been previously employed with this species with conflicting results. In one procedure, the subjects entered the test unit and approached the experimenter (who had already established the cue) on each trial. In the other procedure, the subjects stayed in the test unit throughout a session, witnessed the hiding procedure, and waited for a delay of 10 s during which the cue was provided. The subjects scored at high levels far exceeding chance in response to the gaze cue only when they approached the experimenter for each trial. They performed at chance levels when they stayed inside the test unit throughout the session. They scored at chance levels on all other cues irrespective of the procedure. These findings imply that (a) chimpanzees can immediately exploit social gaze cues, and (b) previous conflicting findings were likely due to the different meta-procedures that were used.

Keywords Gaze following · Joint visual attention · Experimenter-given cues · Chimpanzees

Introduction

Social cues, such as the orientation of the head and eyes of conspecifics, play an important role in the daily interactions of humans and other social primates (Chance 1967; Fehr and Exline 1987). The ability to extract information from conspecifics provides valuable data related to the activities of other members of one's social group, as well as outsiders (e.g., the presence and position of predators; Povinelli and Eddy 1996a). Gaze following, looking where somebody else is looking (e.g. Scaife and Brunner 1975; Butterworth and Cochran 1980; Butterworth and Jarrett 1991), is one mechanism for extracting such information from the behavior of others.

Several species of monkeys and great apes have been shown to follow the gaze of conspecifics and humans (Itakura 1996; Kaplan and Rogers 2002; Lorincz et al. 1999; Povinelli and Eddy 1996a,b, 1997; Povinelli et al. 2002; Tomasello et al. 1998, 1999, 2001). Adult and juvenile chimpanzees reliably follow a human's gaze when it is signaled by eye movements alone (Povinelli and Eddy 1996b), even when eye movements and head movements are dissociated (Povinelli et al. 2002). Although the exact ontogeny of gaze following in chimpanzees and other primates is unclear, this topic is currently under investigation (e.g., Ferrari et al. 2000; Okamoto et al. 2002; Okamoto et al. 2004).

Despite the widespread agreement that chimpanzees (and other species) spontaneously follow the gaze of others, there is considerably less agreement about the ability to use gaze direction to extract certain kinds of social information. Does following a human or conspecific's gaze direction indicate an understanding of the communicative intent of the signal, or are such responses caused by mechanisms unrelated to such social understanding? One experimental technique for exploring this question has come to be known as the object-choice paradigm. In this paradigm, an experimenter typically hides food in one of two locations and then provides a social cue (e.g., gazing, glancing, or pointing) to the food location.

The object-choice paradigm has been used with a number of non-human primate species. Capuchin monkeys, for example, have shown the ability to use experimenter-given cues to locate food, but they have

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only done so in response to a proximate pointing cue that included the experimenter's hand resting on the tray and the index finger being only 15 cm away from the cup (experiments 3 and 5, Anderson et al. 1995). Similar findings have also been reported for rhesus monkeys (Anderson et al. 1996). Itakura and Anderson (1996) trained a capuchin monkey to use several cues such as tapping, pointing, and gazing. Although the subject acquired the skill to use the cues it required considerable training to do so and the cues again were presented quite proximally to the reward location. Furthermore, the monkey failed to learn to use glancing as a cue. Moreover, the distant gazing cue was presumably only acquired because it was presented in a step-wise fashion by presenting the distant cue (60 cm) after the proximate cue (15 cm) had been mastered by the subject. In an additional study, Vick and Anderson (2000) demonstrated that for capuchin monkeys head orientation is a more salient cue than eye direction. These studies highlight that monkeys do not readily use experimenter cues but can learn to do so after extensive training.

Research with great apes has produced a less clear pattern of results. Itakura and Tanaka (1998) reported that two chimpanzees and one orangutan acquired the skill to use five different cues (including glancing) when they were presented in sessions of increasing difficulty. Tomasello et al. (1997), on the other hand, reported that chimpanzees did not reliably use cues (even a proximate pointing cue) to locate a rewarded location. Similarly, Itakura et al. (1999) reported that chimpanzees were unsuccessful at using a combined point/gaze cue to locate the rewarded location (although they performed better when a gaze cue was supplemented with a vocalization). Call et al. (1998) showed that although chimpanzees were following the experimenter's gaze into space above and behind them, they did not use this information to locate food hidden under one of two bowls (although changing the type of the occluder slightly enhanced the subjects' performance). In another study, Call et al. (2000) found that various kinds of noises facilitated chimpanzees' ability to use a gazing but not a glancing cue. Nonetheless, when the authors combined a gazing cue with several behavioral cues (like touching or lifting the cups) most of the chimpanzees could not find the food at above-chance levels. Finally, in an object-choice study with all four species of great apes, Barth, Call, and Tomasello (unpublished data) found that at the individual level none of the subjects reliably used any of the social cues that were presented (gaze, glance, and point).

In contrast to these findings, Povinelli et al. (1999) reported immediate success by their chimpanzees in exploiting a gaze cue. The authors were interested if their subjects would spontaneously generalize their proficiency at using a trained pointing cue to other social cues (such as gazing and glancing). They first trained their chimpanzees to respond reliably to a proximate pointing cue to determine if they could transfer this knowledge to gaze and glance cues. On these transfer tests, the chimpanzees exhibited above-chance performance in the gaze condition that was stable from trial 1 onward. They did not successfully exploit the glancing cue. Furthermore, unlike young 3-year-old children who were tested using the same method, the chimpanzees also used the gazing cue even when the experimenter did not directly gaze at the target but above and behind it. This finding suggests that despite their trial 1 success, in contrast to the human children, the chimpanzees were relying on a gaze-following response that directed them in the general direction of the correct cup, not an understanding of the communicative intent of the gaze.

The discrepant findings from chimpanzees tested in different laboratories on the ability to exploit a distal gaze cue warrants further attention, especially with regard to the role of subject versus procedural factors. The history, age, and gender of the subjects of these studies have been variable, as have been the meta-procedures used. To address this problem, we used a within-subjects design to compare the procedure used in the study by Povinelli et al. (1999) with procedures used in other studies (e.g., Call et al. 1998; Barth, Call, and Tomasello, unpublished data). By using the successful subjects of Povinelli et al. (1999), we were able to test the hypothesis that the discrepant results were the result of procedural, not subject factors. Therefore we modeled our procedures as closely as possible on studies that have previously been conducted. In this study it was not our intention to tease apart which details of a procedure may influence the subjects' behavior.

Methods

Subjects

Seven adult chimpanzees, housed in a social group at the University of Louisiana at Lafayette participated in this study. They ranged in age from 13.2 to 14.1 years when the experiment began. Five of the subjects had been peer raised in a nursery setting, whereas two of the subjects (Apollo and Megan) had been raised by their mothers during the first year of life (before joining the nursery group). The subjects were housed in one group but tested individually in a setting and using procedures that have been described in detail elsewhere (see Povinelli 2000). The animals had participated in numerous other studies involving joint attention, the interpretation of social cues (such as the direction of eyes, head and body, and pointing), as well as numerous studies of the understanding of physical causation (see Povinelli 2000).

Procedure

Overall design The chimpanzees were tested for their ability to use three social cues to locate a food reward: gaze, glance, and midline pointing. Each subject was tested using the exact same cues as presented in the context of two distinct meta-procedures. These two

Table 1 Methodological differences between STAY and LEAVE procedures. *S* Subject, *E* experimenter

Procedural feature	Procedure	
	STAY	LEAVE
Subject position	S stays in test unit for all trials	S enters and leaves for each trial
Training criterion	S trained to select cup that is visibly baited	S trained to select cup to which E points
Food hiding	S observes E hiding food, but not exact location	S does not observe hiding process
Transfer cup	Third cup used to transfer food in hiding process	N/A
Test trial presentation	Test trials presented in blocks	Test trials as probes amid pointing trials
Cue presentation	S awaits each cue onset after hiding process	Cue available to S at trial onset
Cue duration	Cue stops before S is allowed to respond	Cue present as S responds
Subject control	S must wait until 10 s after cue onset to respond	S can respond to cue at any time

procedures will be referred to as the (1) LEAVE procedure (modeled after Povinelli et al. 1999) and the (2) STAY procedure (modeled after Barth, Call, and Tomasello, unpublished data), to reflect one of the most salient differences between the methods (see Table 1 for a detailed comparison of the two procedures).

Testing environment The subjects were tested individually in an environment that consisted of an outdoor waiting area connected by a shuttle door to an indoor testing unit. When the subjects entered the testing unit they were separated from experimenters by a large Plexiglas wall, through which they could respond. They could enter and leave for each trial (LEAVE) or remain in the test unit as each new trial was set up (STAY).

Apparatus Each meta-procedure required a different experimental set-up. For LEAVE, a table (147×30×37 cm) was used to present the task to the subjects. The table was placed 40 cm in front of the Plexiglas partition (Fig. 1a). Two identical square cups (10 cm diameter, 14 cm high) were used to hide the food. The cups were hinged to the table top and were separated by 91 cm. The apparatus was positioned so that the subject could enter and directly reach through either a right or left response hole in the Plexiglas barrier and push over one of the cups. After the subject had responded, the response holes could be remotely closed to prevent a second choice.

For STAY, a table (122×61×40 cm) was used to present the task to the subjects. The table was placed against the Plexiglas partition (Fig. 1b). A panel (108×41 cm) resting on top of the table was used to slide the task back and forth. Three opaque cups were used. A small cup (5 cm in diameter and 6 cm in height) was used to contain the reward (grapes, slices of banana, or juice). Two identical cups (10 cm diameter, 12.5 cm high) were used to hide the food cup. Two small barriers were fastened to the outer corners of the tray to ensure that the two cups were always placed in the exact same location (91 cm apart). On test trials, a rectangular cover (38×38×15 cm) was used to prevent the subjects from seeing under which cup the food was hidden. A Plexiglas panel with two small holes (4 cm diameter) covered the larger holes in the Plexiglas barrier, thereby allowing the subjects to respond only by inserting a finger into the hole corresponding to the cup in front of it.

Orientation The subjects received orientation sessions to familiarize them with the different set-ups and general methods for each procedure. The subjects were randomly divided into two groups (n=3, n=4). In the first session, one group received orientation for STAY and the other for LEAVE. In the second session, the procedures were reversed between groups, and alternated thereafter. For both types of procedures, orientation consisted of six trials per session, during which the reward was placed under each cup on half of the trials. The order of locations was randomized within the constraint that the food was never under the same cup more than twice in a row. Each subject received at least two sessions (one per procedure) each consisting of six trials. A minimum of five correct choices out of six trials per procedure was set as a criterion to advance to testing. Orientation continued until the subjects met criterion on two consecutive sessions.

The specific purpose of LEAVE orientation sessions was to ensure that the subjects would correctly respond to a previously learned proximal pointing cue (see Povinelli et al. 1999). At the start of each trial, the subject waited outside while the experimenter placed a piece of food under one of the two cups. The experimenter then sat on the floor behind the table (so as to be at eye level with the subject) and pointed to the baited cup with extended arm (with the tip of the index finger approximately 5 cm away from the cup). The arm used corresponded to the side of the cup. An assistant opened the shuttle door and closed it behind the subject once he or she entered, allowing the subject to enter and approach the Plexiglas barrier and respond. The subject was allowed to make only one choice (defined as pushing over one of the cups). After each trial, the assistant re-opened the shuttle door, let the subject back into the outdoor waiting area, and closed the shuttle door so the next trial could be prepared. This process of entering and leaving the test unit was repeated for each trial.

The specific purpose of STAY orientation sessions was to be certain the subjects would correctly gesture to a cup that they witnessed being baited. Each trial began by opening the shuttle door and allowing the subject to enter

Fig. 1 Photographs of the test unit showing the differences in the **a** LEAVE and **b** STAY procedures. In LEAVE, the subject entered and left the test unit for each trial. (*I*) The experimenter established the cue before the subject entered. (*II*) The subject approached the experimenter after entering the test unit and chose one of the two cups. In STAY, the subject stayed inside the test unit throughout a session. (*I*) The experimenter placed the cups on the pulled-back tray while the subject was inside the test unit. (*II*) He then concealed the cups and hid food under one of them. (*III*) The cups were placed into their positions and (*IV*) the cue was established and given for 10 s. (*V*) The experimenter then looked straight ahead and pushed the tray forward, allowing the subject to choose one of the cups

the test unit (where it remained for the duration of the session). The two large response cups were placed on the sliding tray (out of the subject's reach) that rested on the table. Once the subject was attentive to the task the experimenter baited the small food cup, showed it to the subject, and placed it in the middle of the tray. The experimenter then showed the subject that the hiding cups were empty and positioned them upside-down with the food cup being in the middle. He then placed one cup over the food cup and slid the two cups into their final positions on the tray. The experimenter used a beeper with an ear-plug to count a delay of 10 s. During the delay, the experimenter looked straight ahead with a neutral face. After the 10-s delay, the experimenter slid the tray up to the Plexiglas barrier so that the subject could respond by poking at one of the cups. A choice before the end of the delay was ignored, unless the finger was still resting in the Plexiglas hole when the tray was slid forward. Once the subject made a choice, the selected cup was lifted and the tray was pulled back. Once the tray was pulled back the second cup was lifted. If the subject had chosen the cup containing the food, the subject was handed the food. If not, the next trial began.

Testing All subjects met criterion for LEAVE, but only five of the seven subjects met criterion for STAY. Because of the within-subjects design, only these five subjects were advanced to testing. They were randomly assigned to two new groups (n=2, n=3). The subjects received blocks of the LEAVE and STAY testing sessions in a counter-balanced fashion. Thus, one group began testing with a block of LEAVE sessions and the other group started with a block of STAY sessions. For LEAVE, each block consisted of six sessions of eight trials each (of which two were probe trials and six were standard proximal pointing trials). The probe trials were always administered on trials 3 and 6. For STAY, each block consisted of two sessions of six trials, each of which were probe trials. Within a session all three cues were given twice (once to the left and once to the right).

For both procedures, during probe trials, the experimenter administered one of three cues to the cup containing the food: (1) gaze (head + eyes), (2) glance (eyes only), and (3) point (looking straight ahead, pointing finger at shoulder level in middle of chest). The cues were delivered in the exact same manner in both LEAVE and STAY by two experimenters whose participation was equated by condition and cue. The type of the cue and the location of the food were randomized and counterbalanced so that the same location was never correct on more than two consecutive trials. For STAY, an additional constraint was imposed so that within a session, for each cue type, the food was in the left and right locations an equal number of trials.

During LEAVE testing, two types of trials were administered: (1) standard trials, in which the experimenter pointed to the baited cup with extended arm and his finger 5 cm away from the cup just as during the orientation sessions, and (2) probe trials, in which the experimenter established one of the three cues (gaze, glance, or point) directed to the baited cup before the subject entered. All cues were given until the subject had chosen. Otherwise, the general set-up and procedures during testing were the same as for the orientation sessions.

During STAY testing, the experimenter used a large opaque cover to prevent the subject from witnessing the hiding procedure. During the hiding procedure, the experimenter made the same sound and movement with both cups to prevent the subject from extracting any auditory or motion cues. When the food was hidden and the cups were slid into their position, the experimenter gave one of the three cues to the cup containing the food, as soon as the subject was attentive. Each cue was given for a duration of 10 s. After the delay, the experimenter looked straight ahead with a neutral face and pushed the tray forward allowing the subject to choose. The subject was allowed to make only one choice. The experimenter then proceeded as in the orientation sessions and administered the next trial.

Videotape coding and reliability assessment

Orientation sessions were independently coded on-line by two assistants. Testing sessions were coded from video records by two observers not involved in acquisition of the data or any other part of the experimental phase of this study. The main observer rated all testing sessions of all five subjects. For "cup-choice" and "hand-use" a second observer rated all testing sessions of two randomly selected subjects (Apollo and Candy). For "premature cup-choice during the delay in STAY" a second rater coded all STAY trials of all animals. The inter-observer agreement was calculated using Cohen's Kappa (κ). Only the coding results of the main observer were used in the data analysis. Three variables from the testing sessions were coded: (1) the cup the subject selected either by turning it over (LEAVE) or by touching it through the hole in the Plexiglas (STAY), for which raters agreed on 99% (239/240) of the trials (κ=0.99), (2) the hand the subject used to make its choice, for which raters agreed on 99% (238/240) of the trials (κ=0.98), and (3) the "premature choices" of subjects during the cue presentation period in STAY (response holes through which the subject protruded a finger before the cue presentation period was completed), for which raters agreed on 88% (104/120) of the trials (κ=0.79).

Results

Orientation

For LEAVE, the subjects that participated in the study required an average of 7 sessions (range 4–13) to reach criterion. For STAY the subjects that participated in the study (n=5) needed an average of 16 sessions (range 9–29) to meet the required criterion of a minimum of five correct choices out of six trials to advance to testing. Subjects that did not show any improvement received a step-wise introduction to STAY in which they were verbally encouraged to respond to the task. However, to reach criterion these subjects had to pass the initial version of the STAY orientation (without any verbal prompting). Two subjects (Jadine and Mindy) did not show any improvement across 21 and 26 sessions, respectively, and were therefore not advanced to the test phase.

Testing

Cup choice Table 2 shows the mean percentage of correct trials per cue for each procedure. A Friedman test revealed an overall effect of condition (χ_5^2=14.1, P=0.015). A comparison of the results per cue and procedure depicted in Fig. 2 shows that the gaze cue in LEAVE was the only cue the subjects reliably used to find the hidden food. All five subjects scored 100% correct in this cue/condition, interpreting the gaze cue in LEAVE correctly on all eight trials. A Wilcoxon paired ranks test showed that all five

Table 2 Mean percentage of correct trials by subject, cue, and procedure

Subject	Procedure						
	STAY			LEAVE			
	Gaze	Glance	Point	Gaze	Glance	Point	Standard point[a]
Apollo	50	38	50	100	50	50	96
Kara	50	63	63	100	50	25	100
Candy	63	63	50	100	63	50	93
Brandy	63	50	50	100	88[b]	38	100
Megan	50	50	75	100	63	88[b]	99
Mean	55	53	58	100	63	50	98

[a]Proximal pointing trials used on standard trials in the LEAVE procedure
[b]$P<0.05$, Binomial test

subjects performed significantly better in the gaze condition in LEAVE than STAY, or any other condition, irrespective of the procedure (all $P<0.05$, two tailed; the P-values have been adjusted for multiple testing by using Hochberg's improved Bonferroni method; Hochberg 1988; Schaffer 1995).

Next we compared the subjects' performance to chance. The only experimental cue in which the subjects (as a group) selected the correct cup at above-chance levels was the gaze cue in LEAVE (binomial test, $P=0.50$, $P<0.001$, two tailed). The subjects chose the correct cup during the standard pointing trials in LEAVE on 351/360 trials (97.5% correct).

Premature cup choice during the delay in STAY The subjects indicated a choice during the delay (by protruding their finger through one of the response holes before the cups were slid to within reach) on 54% of the trials in STAY. Of these trials, the subjects selected the same cup during the delay as after the delay on 69% of the trials. On 54% of the trials the premature choice was the correct choice. Thus, the subjects were also at chance levels in their "premature" choices.

Table 3 Directional handedness index (*HI*) per subject, cue, and procedure. HI was calculated by dividing the difference between the percentage of left and right hand use by their sum (L−R)/(L+R). Negative values indicate a tendency to use the right hand, whereas positive values indicate a tendency to use the left hand (e.g., HI=1 represents exclusive use of the left hand on all trials). *L* Left handed; *R* right handed; *A* ambidextrous (after Hopkins 1999).

Subject	Procedure					
	STAY		LEAVE			
	Probe trials		Probe trials		Standard trials	
	HI	Hand preference	HI	Hand preference	HI	Hand preference
Apollo	−0.84	R	−1.00	R	−1.00	R
Kara	−0.16	A	−0.16	A	0.00	A
Candy	0.92	L	1.00	L	1.00	L
Brandy	−1.00	R	−0.08	A	0.06	A
Megan	0.08	A	0.92	L	1.00	L

Hand use Table 3 shows the directional handedness index (HI, after Hopkins 1999) for each subject per procedure. Different preferences in hand use between the procedures may indicate, at a simple behavioral level, that the responses of the subjects were influenced by the procedures. One subject showed a strong preference to use his right hand to select the cups irrespective of the procedure (Apollo). Another subject showed the same pattern for the left hand (Candy). Kara did not show any preference for either hand irrespective of the procedure. However, for both Brandy and Megan the preferred hand to make their choice was dependent on the procedure, indicating that for these two subjects, at least, the different procedures significantly affected a rather fundamental aspect of their behavior.

Archival analysis of learning effects Finally, to determine if our subjects' ability to exploit the gaze cue in LEAVE was learned, we compared the archival data from the three previous studies in which LEAVE had been used with these five subjects. Two of these studies are reported in Povinelli et al. (1999), and one is from an unpublished

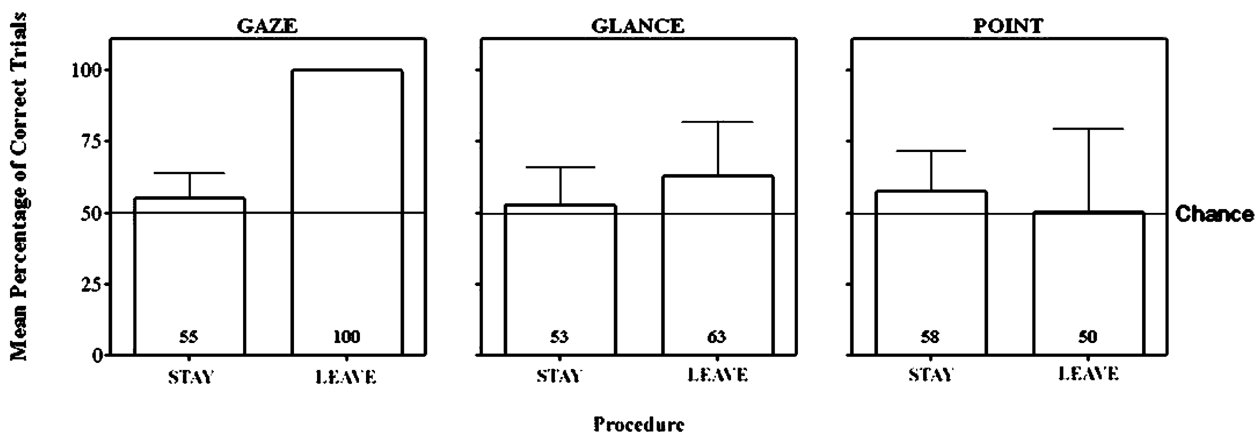


Fig. 2 Mean percentage of correct trials (±SD) per cue and procedure. Each graph represents the mean score of 40 trials (8 trials per subject)

study (conducted approximately 3 years after the first two studies) archived in the Cognitive Evolution Group data archives (available upon request).[1] These data, along with those from the present study, are plotted in Fig. 3. Although the subjects do exhibit some improvement across experiments in response to the gaze cue, as can be seen, the subjects were above chance from the very first block of two trials and maintained a high performance level across each subsequent replication. In contrast, comparable improvement is not seen in response to the glance cue. (Although the fundamental stability of performance in response to the gaze cue indicates it was not a factor, it should be noted that there was one difference across these experiments in how the cues were presented. In experiment 1, as in the present experiment, the cues were presented statically, with the experimenter gazing or glancing at the correct location. In experiments 2 and 3, the cues were presented dynamically, with the experimenter moving his or her head or eyes back and forth between the subjects and the correct location).

Discussion

This study investigated the influence of two different experimental procedures on chimpanzees' use of three social cues in an object-choice task. All five subjects selected the correct cup when the experimenter gazed at it, but they were only able to do so in one of the procedures (LEAVE). This difference is all the more striking given that all five subjects selected the correct option on all 100% of the gaze trials in the LEAVE procedure. The other cues (pointing, glancing) were not reliably used in either procedure. Given the counter-intuitive nature of these results (i.e., that such a seemingly small procedural difference could have such a large impact on the subjects' performance), as well as the implication that our results have for previous research that has not used the LEAVE method, in what follows we critically examine several key issues concerning both the present study and previous studies in this area.

First, it could be argued that the ease with which the subjects used the gaze cue in LEAVE was due to their previous experience with this procedure (e.g., Povinelli et al. 1999). However, it is unlikely that the history of our subjects explains the differential results we obtained in the STAY and LEAVE methods in the present study. As can be seen in the results of experiment 1 in Fig. 3, our subjects were able to exploit the gaze cue from the very first time they were confronted with it (see Povinelli et al. 1999). The effect of the subjects' experience with the gaze cue in the LEAVE method only explains the increase in performance from 80% correct trials on their first encounter with the LEAVE method in the 1999 study to the 100% correct trials in the present study, not their initial (and stable) ability to exploit the cue. Further, the subjects did not show any improvement in using the LEAVE glance cue (pointing was not included in the previous study, but see Povinelli et al. 1997). Finally, it is important to reiterate that these same subjects were unable to exploit an identical social cue in the STAY procedure. This strongly suggests that what we have described as the STAY procedure may mask abilities that are in fact present.

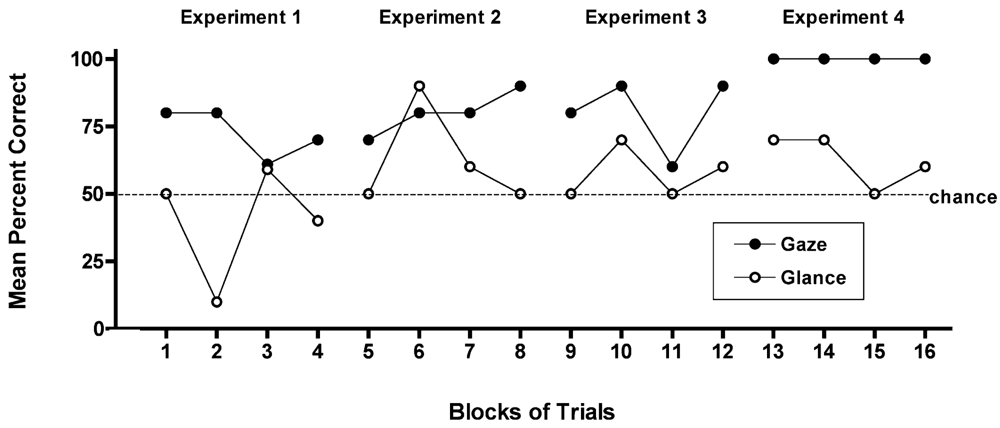
Second, with respect to the subjects' chance-level performance in the STAY procedure, we examined whether the subjects had made a correct choice during the delay but then changed their choice because the experimenter did not immediately respond. The results clearly show that even though the subjects did, in fact, make a response during the delay on more than half of the trials, their choices were as often correct as incorrect. Therefore, by itself, the delay in the STAY procedure is unlikely to explain the subjects' chance-level performance.

Third, the results confirming the subjects' lack of use of the glance (eye movement alone) and midline pointing cues may be explained by the salience of these cues. In the case of the glancing cue, although chimpanzees show a gaze-following response based on eye direction alone (Povinelli and Eddy 1996a), in the context of an object-choice task glancing might not be a salient enough cue to direct the subject in the direction of the correct cup. In the case of the midline pointing cue, previous studies have suggested that chimpanzees rely on proximity features of pointing cues (Povinelli et al. 1997). Presumably, for the chimpanzees a pointing cue with an index finger that is equidistant to both cups, so that proximity cues are neutralized, does not draw the chimpanzees' attention preferentially toward one of the two locations.

Fourth, although further studies are necessary to isolate exactly the methodological factors that allow chimpanzees to exploit the gaze cue in one method but not the other, at present the approach toward the experimenter in the LEAVE method would seem to be the most likely factor. In a previous study (Povinelli et al. 1999) it was found that chimpanzees, unlike children, also use a gazing cue that is not directed at the cup, but above the cup (above-target condition). This finding was interpreted as reflecting that the chimpanzees were directed in the general direction of the correct cup by their natural gaze-following response when approaching the experimenter, in contrast to an understanding of the communicative content of a cue that creates a triadic connection. The results of the present study can be interpreted in a similar fashion. In the LEAVE procedure, the subjects entered the test unit, and while approaching the experimenter and apparatus, their automatic responses to the experimenter's fixed head and eye orientation directed their attention (and hence primed their responses) toward the position of the correct cup. The STAY procedure, in contrast, may limit the subjects' abilities to exploit this cue because of attentional factors

[1] It should be noted that other studies involving these subjects' use of gaze cues to locate objects, using different procedures, were conducted between the first two experiments of Povinelli et al. (1999) and the archived replication study (see Povinelli et al. 1997, 2002). These published data merely reinforce our point concerning the subjects' initial and stable above-chance performance in responding to the gaze cue using the LEAVE method.

Fig. 3 Learning curves for the gaze and glance cues across four consecutive experiments. The data are from three previously conducted experiments (blocks 1–12; see text) and the present experiment (blocks 13–16). Each data point represents the grand mean score of five subjects (two trials per subject)



related to repeated movements and incidental orientations on the part of the experimenter as each trial is being prepared. In this context, the change of hand preference that we observed in two of our subjects also suggests that the subjects changed to a different response mode during the STAY procedure. A shift in hand preference from standard trials in the probe trials of the STAY but not the LEAVE procedure may reflect uncertainty or confusion.

To the best of our knowledge, the LEAVE method in the present study (along with the previous studies cited above involving these subjects) differs from all other research on the ability of chimpanzees to exploit human cues in the object-choice paradigm in that the subjects approach the experimenter on each trial. However, even though we showed that these subjects (a) responded in a robustly different manner to the STAY and LEAVE methods and (b) that this is unlikely to be the effect of differential experience with the LEAVE method, it will be important to replicate our findings with a group of naïve subjects. Also, because no studies have been conducted with any species of monkeys using the LEAVE method, it would be of great interest if monkeys, like our apes, were able to exploit an experimenter's gaze cue using this method without requiring extensive training. Thus, given the increasing use of object-choice tasks that involve experimenter-given social cues, our results suggest that greater attention should be devoted to the exact methods used within this paradigm. Our results open the possibility that some methods used in previous studies might have masked an ability to exploit human-given cues (regardless of the underlying cognitive processes supporting that ability).

This attention should be extended to non-primate species, as well. For example, with respect to the recent results suggesting that dogs are superior to apes in using experimenter-given cues (e.g., Agnetta et al. 2000; Hare et al. 2002; Hare and Tomasello 1999; Soproni et al. 2001), it would be crucial to evaluate the effect of different methods on the dogs' performance. In these studies, the subjects typically approach the experimenter from a distance (i.e., the LEAVE method). It would be of interest to know if they perform equally well if they are sitting in front of the experimenter. After all, our results show that in response to certain cues, apes can be highly adept at exploiting them, so long as the correct meta-procedure is used. The effect of these different methods should also be ruled out when comparing dogs with wolves, as in Hare et al. (2002), especially because in this case wolves were tested from behind a mesh fence and, unlike the dogs, were not approaching the experimenter. That is, the dogs were tested using the LEAVE method, whereas the wolves were tested using the STAY method. As we have shown here, it is problematic to draw conclusions about performances across these two meta-methods.

Finally, a comparison of these methods should also be conducted with human subjects. The few studies that have been conducted with children all showed that children around 3 years of age are successful in using social cues to find hidden objects (e.g., Itakura and Tanaka 1998; Povinelli et al. 1997, 1999; Tomasello et al. 1997). The procedures used in these studies were similar or comparable to either the LEAVE or the STAY procedure. This would suggest that for the children the ability to use social cues does not depend on the meta-procedure.

In conclusion, future studies testing the ability of animals to exploit human-given social cues in object-choice tasks should display greater sensitivity to the meta-methods that are used and should take these methods into consideration when interpreting the results across different species, as well as across different groups of the same species tested in different laboratories.

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