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Use of Human Visual Attention Cues by Olive Baboons (*Papio anubis*) in a Competitive Task

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The ability of 4 olive baboons (*Papio anubis*) to use human gaze cues during a competitive food task was investigated. Three baboons used head orientation as a cue, and 1 individual also used eye direction alone. As the baboons did not receive prior training with gestural cues, their performance suggests that the competitive paradigm may be more appropriate for testing nonhuman primates than the standard object-choice paradigm. However, the baboons were insensitive to whether the experimenter could actually perceive the food item, and therefore the use of visual orientation cues may not be indicative of visual perspective-taking abilities. Performance was disrupted by the introduction of a screen and objects to conceal food items and by the absence of movement in cues presented.

Research has shown that animals are sensitive to human visual attention, insomuch as behavioral phenomena, such as tonic immobility (Gallup, 1972), injury feigning (Ristau, 1998), and flight responses (Hampton, 1994), are influenced by whether a nearby human is looking at the animal. However, studies on animals' abilities to coorient and exploit non–self-directed gaze have been limited to a few species: primarily primates but also domestic dogs and horses (Anderson, Sallaberry, & Barbier, 1995; Call, Hare, & Tomasello, 1998; Hare & Tomasello, 1999; Itakura, 1996; McKinley & Sambrook, 2000; Miklosi, Polgárdi, Topál, & Csanyi, 1998; Povinelli & Eddy, 1996a, 1996b, 1996c).

Within this domain, the study of primates' abilities to monitor and exploit the gaze information of others is almost exclusively restricted to two experimental paradigms: visual coorientation and object-choice tasks. These paradigms have produced divergent results. Visual coorientation with humans or conspecifics has been demonstrated in great apes and several species of monkeys. Thus, nonhuman primates are sensitive to variations in both head and eye orientation in terms of visually inspecting locations congruent with another's gaze (Anderson & Mitchell, 1999; Call et al., 1998; Emery, Lorincz, Perret, Oram, & Baker, 1997; Ferrari, Kohler, Fogassi, & Gallese, 2000; Itakura, 1996; Lorincz, Baker, & Perrett, 1999; Povinelli & Eddy, 1996b; Tomasello, Hare, & Fogleman, 2001). Coorienting with another individual's line of regard is undoubtedly advantageous for social animals such as primates; important information regarding predators, food sources, and social events, for example, may be acquired through a simple gaze-following mechanism (Kummer, 1967). Indeed, this behavioral mechanism is represented at the neurophysiological level with cells in the superior temporal sulcus and amygdala specialized for processing information concerning gaze (Campbell, Heywood, Cowey, Regard, & Landis, 1990; Emery, 2000; Perret et al., 1985).

The second main experimental paradigm, the object-choice task, has revealed some limitations of gaze following by primates. This task requires the subject to use experimenter-given cues, such as pointing or looking, to locate a hidden food item in, under, or behind one of two objects presented. A distinction has been made between a tendency to coorient so that both individuals are oriented in the same direction, thereby increasing the likelihood of discovering a common object, and an ability to accurately focus on the object of another's gaze (e.g., joint attention; Moore & Dunham, 1995). Ostensibly, the object-choice task could be solved using simple coorientation, in that looking where the experimenter looks should heighten the probability of choosing the first object encountered and retrieving the food item. This does not seem to be the mechanism invoked by the object-choice task; despite their ability to track gaze, primates often have serious difficulties in mastering the object-choice task.

Although some great apes and monkeys tested on object choice are able to use experimenter-given cues up to and including eye direction alone (Itakura & Tanaka, 1998; Vick & Anderson, 2000), there are complicating factors, including the identity of the cue giver (Itakura, Agnetta, Hare, & Tomasello, 1999; Vick & Anderson, 2000) and the extent of early social experience with humans (Call et al., 1998; Itakura & Tanaka, 1998; Peignot & Anderson, 1999; Povinelli, Biershwale, & Čech, 1999). In addition, Call et al. (1998) suggested that the type of object used to conceal food items may influence performance and that the experimenter should actually be able to perceive the food item while cuing. However, during an object-choice task, chimpanzees' choices of object were relatively insensitive as to whether the experimenter was accurately oriented toward an object, let alone perceiving the food item. (Although the chimpanzees did visually coorient with an experimenter looking above the container; Povinelli et al., 1999. But see Tomasello, Hare, & Agnetta, 1999, for more sophisticated performance within a gaze-following paradigm.) Moreover, for monkeys, explicit training in object-choice gaze exploitation may be

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required; monkeys are usually given prior experience with manual gestures such as pointing before they master gaze orientation as a cue (Anderson, Montant, & Schmitt, 1996; Anderson et al., 1995; Itakura & Anderson, 1996; Vick & Anderson, 2000).

It is conceivable that the apparent difficulty with the object-choice task is due to the fact that it is based on cooperation between the experimenter and subject; primates (or at least those with limited human contact) may be less likely to demonstrate their gaze-monitoring abilities in such a context (Call, Agnetta, & Tomasello, 2000). That is not to say that nonhuman primates fail to see human experimenters as interactants; they readily respond to human eye contact with appropriate behavioral responses (Exline & Yellin, 1969; Kummer, Anzenberger, & Hemelrijk, 1996; Thomsen, 1974). However, the object-choice task may neglect an important point: For nonhuman primates, access to resources is usually more a matter of competition than of cooperation (Byrne & Whiten, 1988; Coussi-Korbel, 1994; Dawkins & Krebs, 1978; Peláez, Gil-Burmann, & Sánchez, 2000; Schaub, 1995). Viewed from this perspective, the interaction with a human experimenter sitting behind (and effectively controlling access to) food is intrinsically a competitive one (Hare, 2001; Ristau, 1998)

Thus, an alternative way to study gaze monitoring is to adopt a competitive approach. Kummer et al. (1996) investigated long-tailed macaques' use of visual perspective taking to conceal themselves from a human experimenter and gain access to a desired resource; the monkeys failed to engage in effective hiding behaviors (and hence demonstrate effective gaze monitoring). Nevertheless, nonhuman primates may display their abilities to monitor the visual orientation of others more readily in other situations characterized by competition over resources, as suggested in reports of tactical deception (Byrne & Whiten, 1988) and in patterns of social monitoring (Blois-Heulin & Girona, 1999) and behavior (Hare, Call, Agnetta, & Tomasello, 2000; Hare, Call, & Tomasello, 2001) during food competition. As Hare (2001) states,

> the lives of all primates are dominated by intense competition with conspecifics. All environments have finite supplies of resources on which survival and reproduction are dependent. . . . In species as diverse as ring-tailed lemurs, squirrel monkeys, and chimpanzees the majority of the day is spent in the company of one's most intense competitors: conspecifics. (p. 721)

Experiment 1

The present experiment was derived from the object-choice approach, but the task was modified to become competitive rather than cooperative. Instead of being required to follow the experimenter's gaze to locate and select a baited object, the baboons needed to monitor the experimenter's visual orientation to take the one of two visible food items presented that the experimenter was not looking at. Note that this also means the task could not be performed on the basis of simple gaze following, as this would lead to an incorrect response. As this experiment aimed to improve approximation of naturalistic competition over food, the baboons were not explicitly trained to monitor the experimenter's gestures as in previous object-choice studies with monkeys; instead, they were simply presented with head and/or eye orientation. In a previous study (Vick, Bovet, & Anderson, 2001), baboons were presented with these same cues in a standard object-choice task without any scaffolding with manual cues. The baboons did not exploit either head or eye gaze, although 1 baboon showed signs of learning to respond to head direction as an information source after several hundred trials. Thus, the present study allows a within-species comparison on the two tasks; will a competitive context be more conducive to using another's gaze?

Method

Subjects. The monkeys were 4 adult olive baboons (*Papio anubis*): 2 captive-born males, Sylvestre (18 years old) and Balthazar (15 years old), and 2 females, Ida (6 years old and captive born) and Green (7 years old and wild born). The baboons were housed in two groups (one with 9 members and the other with 7 members) in indoor–outdoor quarters (35 m $\times$ 35 m each) at the Centre Nacional de la Recherche Scientifique (CNRS) Station de Primatologie in Rousset-sur-arc, France. All the baboons except Green had previously been tested on a categorization task (Bovet & Vauclair, 1998). Balthazar and Ida had been tested on the object-choice task 12 months before the present study commenced. (Neither had performed at above-chance levels; Vick et al., 2001.) All baboons received their daily food ration (fruit, dried pellets, and vegetables) at the end of daily training and testing. Standard food items (pieces of fruit) and treats (nuts, raisins, and cereals) were used during test sessions.

Apparatus. The apparatus consisted of a wooden tray (60 cm $\times$ 40 cm) that rested on a table (50 cm $\times$ 30 cm $\times$ 40 cm). The tray's midline was marked from front to back, and a small square (2 cm $\times$ 2 cm; 10 cm in from the front and side of the tray) was marked on each side of the midline. A chronometer was used to signal 5 s intervals.

Procedure. The tray was placed about 50 cm away from the enclosure fence for baiting. The experimenter (Sarah-Jane Vick) sat in a neutral posture behind the tray and, while fixating on the center of the tray, placed a food item on each of the two squares simultaneously; the food items were the same type and size within each trial. The experimenter's head and eyes were approximately 50 cm from the food items. The experimenter presented the cue condition for 5 s and then, maintaining the cue, pushed the tray against the mesh wall of the enclosure to allow the baboon to respond.

Baboons were tested in the presence of other group members, although any individuals of higher dominance rank were restricted to the indoor area during the testing sessions. Each baboon was presented with 30-trial sessions, with a baseline session preceding each block of five cue-condition sessions. For baseline sessions, the experimenter looked down at the midline at the near side of the tray, whereas for cue conditions, she oriented her head and/or eyes toward one of the food items. The correct side was the side that the experimenter was not oriented and/or looking toward. The baboons responded by reaching toward one of the food items. If they reached toward the nonfixated side, they were permitted to take the food item and consume it. However, if they reached for the side that was oriented toward the experimenter, the tray was quickly pulled away so that they could not take the food item, and the experimenter then pretended to consume the food item.

The intertrial interval was approximately 30 s. Both sides were oriented toward an equal number of times, with the constraint that no more than three consecutive trials were allowed in which the cue was presented to the same side. Two baboons commenced with a head and eyes orientation condition (Balthazar and Ida), and the other 2 (Sylvestre and Green) were first presented with the eye direction only condition. Each baboon continued in a given condition until they reached a mastery criterion of 80% correct for two consecutive sessions within a five-session block (which they then completed) or until they had completed 25 sessions; the baboons were then presented with the alternative cue condition. One to three sessions were conducted daily with a minimum interval of 15 min between sessions.

Results and Discussion

Individual performances are illustrated in Figures 1 and 2. The baboons reached for one of the two food items on every trial, showing their full participation in the competition for food. Performance was tested against chance response levels using binomial tests. Only 1 baboon (Ida) reached the mastery criterion of 80% correct in the first cue condition presented—the head and eyes orientation condition; she was above chance performance in four of the five initial sessions ($p < .05$) and at 80% or above for Sessions 6–10 ($ps < .01$; see Figure 1A). Balthazar, presented with the same cue condition, performed consistently above chance (with the exception of one session) from Session 11 onward ($p < .05$), but he failed to meet the mastery criterion of 80% correct (see Figure 1A). In contrast, both subjects presented with the eye direction only condition were at chance levels throughout the 25 sessions (with the exceptions of one cue and one baseline session for Sylvestre; see Figure 2B).

In their second conditions, 2 of the 4 baboons reached the mastery criterion. Ida successfully mastered the eye direction only condition after 11 sessions (see Figure 2A). Green reached criterion in the head and eyes orientation condition after seven sessions, although she performed significantly better than chance from Session 3 onward ($p < .05$, with the exception of Session 6; see Figure 1B). Balthazar and Sylvestre failed to reach criterion in the eye direction only and head and eyes orientation conditions, respectively. Although Sylvestre did perform at above-chance levels ($p < .05$), in 8 out of 10 sessions from Session 6 onward, he did not maintain a consistent level of performance (see Figure 1B). These results establish that the competitive approach is an appropriate method for assessing gaze monitoring; this is the first evidence of baboons demonstrating an ability to master gaze cues in a problem-solving interaction.

Immediately following initial testing, the performance of 3 of the baboons was further explored. Supplementary testing with Sylvestre revealed that he was able to master a point and gaze (head and eyes) cue condition, avoiding the indicated food item with significant regularity from the second session ($p < .05$) and reaching an 80% correct level by Session 7. Thus, Sylvestre's previously poor performance was not attributable to a lack of motivation. Because he reached the mastery criterion with pointing as a cue, he was again presented with only the experimenter's head and eyes oriented toward the food item (10 sessions). However, his performance immediately fell to chance levels (M = 60.3% correct); even after 300 trials he was unable to respond on the basis of head and eye orientation.

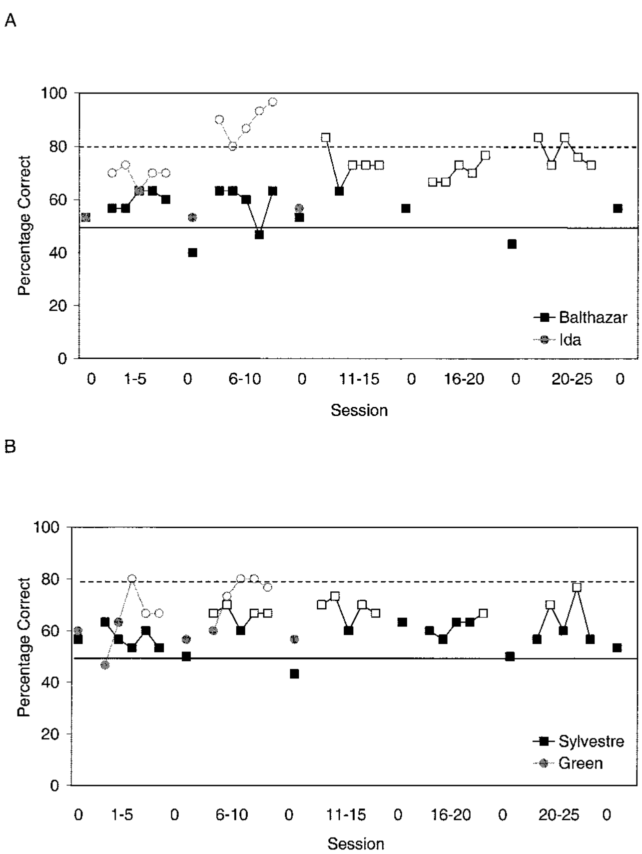

Figure 1. Performance in the head and eyes orientation condition. A: Ida and Balthazar. B: Green and Sylvestre. Each zero represents a baseline session. Open data points represent above-chance performance ($p < .05$). Solid horizontal lines represent chance performance; dotted horizontal lines represent the 80% correct level.

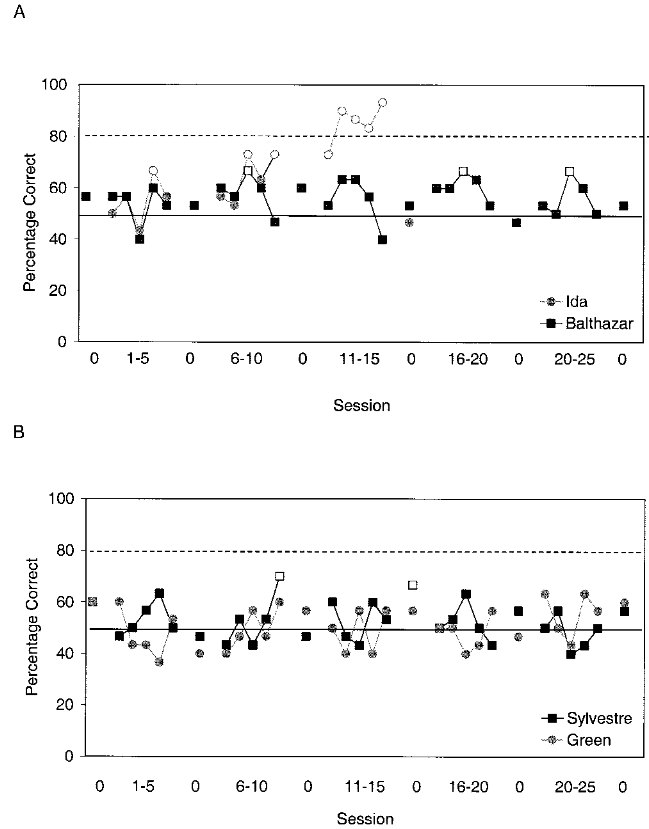

Figure 2. Performance in the eye direction only condition. A: Ida and Balthazar. B: Green and Sylvestre. Each zero represents a baseline session. Open data points represent above-chance performance ($p < .05$). Solid horizontal lines represent chance performance; dotted horizontal lines represent the 80% correct level.

Because Green had mastered the head and eyes orientation condition, she was again presented with the eye direction only condition, so that we could exclude order effects as an explanation for her superior performance in the former condition. After 25 sessions (750 trials), she remained at chance levels ($M = 55.9\%$ correct).

In summary, 1 baboon mastered both the eye direction only and head and eyes orientation conditions, 1 mastered the head and eyes orientation condition but not the eye direction only condition, and 2 failed to reach mastery criterion levels of performance in both conditions (although 1 of these did perform consistently at above-chance levels when presented with the head and eyes orientation condition). Combined head and eyes orientation appears to be a more effective cue than eye direction alone: 2 baboons reached the mastery criterion and 1 performed consistently above chance when head orientation was a component of the cue, whereas only 1 baboon mastered the eyes only cue. Moreover, although Ida mastered both conditions, she did so more rapidly in the head and eyes orientation condition (in Session 6, compared with Session 12 for the eye direction only condition). A second baboon (Green) was unable to master the eye direction only condition, even after receiving a total of 1,500 trials. These results converge with other evidence that monkeys more readily use head direction rather than eye direction alone as an experimenter-given cue in object-choice tasks (Anderson et al., 1996; Itakura & Anderson, 1996; Vick & Anderson, 2000) and perhaps also within a broader gaze-following paradigm (Ferrari et al., 2000).

The results of this experiment demonstrate that olive baboons are able to learn to use the gaze cues of a human experimenter without requiring prior training with more explicit gestural cues. Although this could suggest that baboons are more adroit at reading gaze than other species, for which manual cues appear to be facilitatory (Itakura & Anderson, 1996), this seems an unlikely explanation. A previous object-choice study with olive baboons, which did not incorporate scaffolding in the form of manual cues, resulted in only 1 of 4 baboons learning to use (but not master) an experimenter-given cue (head orientation) after 700 trials (Vick et al., 2001).

Experiment 2

Given that 3 of 4 baboons demonstrated an ability to use head and eye orientation as cues in Experiment 1 (2 meeting the mastery criterion of 80% correct and 1 performing consistently above chance levels), we set out to further explore this ability. The first manipulation concerned the role of motion in head orientation as a cue. Object-choice tasks have typically presented static gaze cues (Anderson et al., 1995, 1996; Itakura & Anderson, 1996), and it could be that the presence of movement facilitated the exploitation of cues in the competitive situation used in Experiment 1. Call et al. (2000) have proposed that motion may enhance performance both by acting as an attention getter (emphasizing the experimenter's actions) and by providing directionality. However, the addition of movement to head and/or eye orientation cues in an object-choice task with chimpanzees did not improve performance (Povinelli et al., 1999; but see Povinelli & Eddy, 1996b, for contrasting evidence using a trainer-choice task). Thus, it remains unclear whether motion facilitates the reading of visual orientation cues.

In the second manipulation we attempted to determine the baboons' level of understanding of looking behavior: Although only 1 baboon used eye direction explicitly, was there any evidence of a more implicit influence of the eyes (Moore, 1999), and how accurate were the baboons in discerning the focus of gaze? Whereas all but 1 of the baboons were unable to compete effectively on the basis of eye gaze direction alone, baboons might be sensitive to a grosser cue concerning the role of eyes in visual orientation—that is, whether the eyes are open or closed (Corkum & Moore, 1995; Povinelli & Eddy, 1996b). In terms of actual focus of gaze, it has been proposed that a high-level understanding of gaze predicts that subjects should respond differentially according to whether an experimenter is looking at or above an object. A low-level model, based on more general coorienting responses to grosser behavioral indices, would not predict such accuracy in identifying the target of another's gaze (Povinelli et al., 1999).

We included a final manipulation to identify possible sources of monkeys' difficulty with the typical object-choice task. Is competition more conducive to cue reading, or is the difficulty in object choice at least partially due to other features of the procedure? For example, might the use of objects and a screen somehow distract the baboons from the task of monitoring experimenter-given cues? There are several ways in which the introduction of screen and objects could change the task for the baboons. For example, concealing the food items might alter the motivational salience of the situation (Boysen & Bernston, 1985). In addition, it has long been known that introducing a screen during delays diminishes performance on delayed-response tasks (Fletcher, 1965); the screen and objects might simply increase the complexity of the task and distract from cue reading.

Method

Subjects and apparatus. Three of the baboons tested in Experiment 1 were tested in this experiment: Balthazar, Green, and Ida. The basic apparatus was the same as that used in Experiment 1. Additional items were a cardboard screen (100 cm × 80 cm) and two identical yellow plastic cups (6-cm diameter × 6-cm height).

Procedure. Four consecutive sessions were conducted with each of the three new manipulations (movement, cue type, and objects), with baseline sessions separating each of these blocks. In all sessions, subjects were presented with 10 trials of the previously mastered head and eyes orientation condition pseudorandomly mixed with 10 each of two new trial types. That is, there were 30 trials per session, with the three experimental conditions presented in a randomized order.

In the movement sessions, in addition to the standard cue trials, the baboons were presented with static cue trials. Following the usual baiting procedure, a handheld screen (100 cm × 80 cm) was interposed between the experimenter and the baboon to conceal the movement of the experimenter's head and eyes toward one of the items; the screen was then removed and the trial proceeded as previously described. To control for any effects of the introduction of the screen, we included a third trial type (movement plus screen) that incorporated the screen as above; however, the experimenter did not move her head or eyes until after the screen was removed, producing a standard trial in which the screen was irrelevant.

In the cue type sessions, two novel conditions were presented: an eyes closed condition, with the head oriented as in control trials but with the eyes closed before the head was turned, and a general direction condition, in which the experimenter oriented her head and eyes to the side but upward (about 30° from the neutral head position) instead of down toward the food item. Because the experimenter was not looking at the food item in either of these new trial types, she maintained the cue position for 5 s after presenting the tray and then the baboon's choice of food item was noted. Thus, the baboons received a reward regardless of their choice of food item.

In the objects sessions, two identical containers were used to conceal the food items; baiting was done as in standard trials, and then the two cups were placed over the food items. For half the trials (objects only condition), the trial then proceeded as in control trials, with the baboon simply having to move the object to retrieve the food item (which they readily did). For the remaining trials (objects plus screen condition), a screen was introduced once the cups had been put in place; the screen was held in place for 5 s and then removed before the trial continued.

Results and Discussion

Movement. As can be seen in Figure 3, overall performance remained high in the standard cue condition ($M = 85.0\%$ correct; ps $< .05$) but deteriorated in both the static cue and movement plus screen conditions (Ms $= 65.8\%$ and 72.5%, respectively). A Friedman's test indicated a marginally nonsignificant effect of condition, $r_F = 5.64$, $p = .06$. Consideration of individual scores revealed that although performance deteriorated when the cue was static (to chance levels for 2 of the 3 baboons: 22/40 and 21/40 for Balthazar and Green, respectively; 36/40 for Ida, $p < .01$), there was also a decrease in response to the introduction of the screen even if movement was retained. However, performance did remain above chance levels for 2 baboons and approached significance for the third (Balthazar, $p < .05$; Green, $p = .08$; Ida, $p < .01$). That is, although the screen diminished performance levels whether the cue was static or dynamic, the absence of motion led to a greater deterioration in performance.

Cue type. Overall, the baboons performed significantly above chance in the standard cue condition ($M = 79.0\%$ correct, $p < .05$) as well as in both of the new conditions: eyes closed ($M = 74.2\%$; $p < .05$, $p = .08$, and $p < .01$, for Balthazar, Green, and Ida, respectively) and general direction ($M = 73.3\%$; $p < .01$, $p = .08$, and $p < .01$, for Balthazar, Green, and Ida, respectively). A Friedman test showed no significant effect of condition: The baboons continued to respond to the head orientation cue regardless of whether the eyes were open or closed and also when the experimenter was not directly looking at the food item, $r_F = 0.06$, $p = .76$. Because the baboons were able to take either of the food items on the tray, a Friedman's test was used to assess whether the baboons learned across sessions that the experimenter was not monitoring the food items. The results showed no effect of session on performance in these conditions (eyes closed: $r_F = 3.96$, *ns*; general direction: $r_F = 3.00$, *ns*).

Objects. Performance in the standard cue condition was above chance for all 3 baboons ($M = 81.6\%$ correct; ps $< .05$), but overall performance showed a considerable decrease in both the objects only and objects plus screen conditions (Ms $= 72.5\%$ and 68.3%, respectively). A Friedman's test showed a near-significant effect of condition, $r_F = 5.64$, $p = .06$. Analysis of individual performances revealed that with both the introduction of the objects and the objects plus screen, performance remained above chance levels for both Green and Ida (ps $< .01$) but approached significance only for Balthazar in both conditions ($p = .08$). An analysis of performance across sessions addressed possible novelty effects, but the baboons showed no significant change across the four sessions (objects only: $r_F = 2.78$, $p = .43$; objects plus screen: $r_F = 2.52$, $p = .47$).

The results of Experiment 2 suggest that although the baboons had learned to take the experimenter's head orientation into account when performing the competitive task, their performance was diminished by procedural modifications including concealing the food items with objects and a screen and, to a lesser extent, omitting movement from the cue. Previous negative findings for monkeys presented with gaze cues may therefore reflect the methods used in the object-choice task as much as an inability to use the cues themselves. For example, successful performance following training may at least partially reflect habituation to the objects and

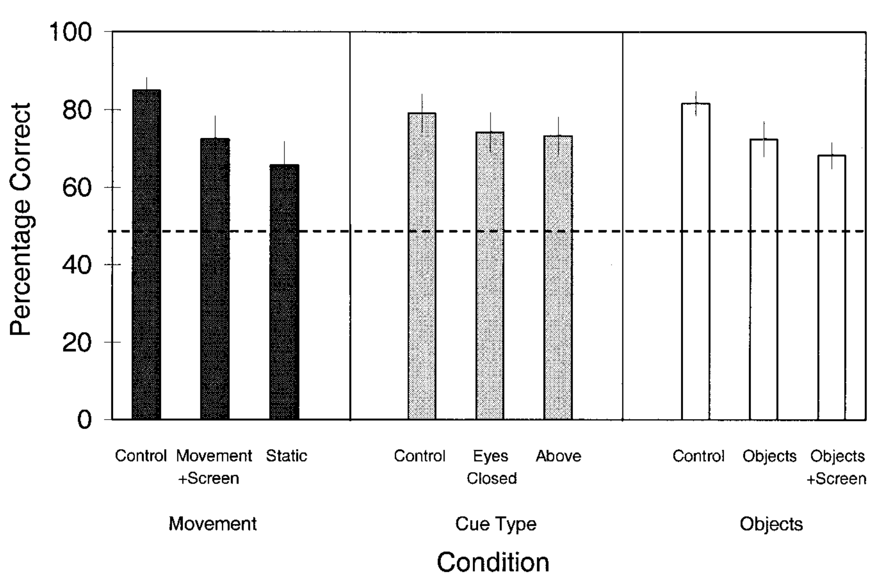

Figure 3. Means for performance in movement, cue type, and objects conditions (Experiment 2). The dotted horizontal line represents chance performance (50%). Error bars represent standard errors of the means.

screens used. However, because performance in the present experiment did not improve across sessions, this appears to be more than a mere novelty effect.

The addition of movement may make gaze cues more salient, at least for head orientation, suggesting that presentation of static cues may also impede cue reading by nonhuman primates. It has been proposed that changes in head direction may be a more effective cue (than eye gaze) because they provide a stronger motion transient (Hood, Willen, & Driver, 1998). It is interesting that the addition of movement within this competitive paradigm could not enhance performance merely by eliciting visual coorientation with the experimenter (as might be the case in an object-choice task). Instead, head movement simply made the direction of the head more salient for the baboons (see also Call et al., 2000).

The results of the cue manipulations are noteworthy: The baboons continued to respond according to previously learned rules when the experimenter could not see the food item, that is, when the eyes were closed and even when the orientation of the head itself (or eyes in Ida's case) was not aligned with one of the food items. It is conceivable that the baboons simply continued to respond in a manner that they knew to be successful. Even if they were aware of the experimenter's eyes being closed or that the head was oriented above rather than toward the food, they knew from past experience that choosing the food item not aligned with the experimenter's head orientation was a guaranteed strategy for success. However, the baboons failed to learn from their occasional errors that food items could also be removed from the side congruent with head orientation in over half the trials presented. Overall, it appears that the baboons were responding on the basis of past experience and not making any relevant assessment of the experimenter's visual orientation (as also suggested by Povinelli & Eddy, 1996c). Alternatively, the lack of sensitivity to eyes could also be due to the availability of head direction. That is, baboons may be sensitive to whether the eyes are open or closed but not within a context in which head direction is providing directional information (Moore, 1999). However, 2 of the 3 baboons also failed to respond to eye gaze when this was the only cue presented, suggesting that head orientation might simply be a more salient cue than eye direction.

General Discussion

The results of these studies suggest that although primates may coorient with others as a means of locating important events or objects, they are also sensitive to the gaze cues of others on another level. Namely, they can exploit this information competitively in certain circumstances (see also Byrne & Whiten, 1988; Hare, 2001). As with visual coorientation, such a skill may be the result of simple associative learning. For example, primates may learn that head orientation is a good signal of whether a dominant individual is likely to become aggressive over access to food or mating opportunities. As Cheney and Seyfarth (1991) stated, modifying behavior in response to other individuals' orientation and direction of gaze "certainly demands that monkeys recognise that attentiveness can strongly affect actions" (p. 193), but it does not require any appreciation of the underlying mental states of attention.

The 2 baboons that quickly learned to exploit the experimenter's visual orientation, at least as indicated by head orientation, were females. Possibly, the males acted less on gaze cues because they were less accustomed to losing competitions for resources; in this captive environment, a single adult male can enforce exclusive access to receptive females and priority access to food. Alternatively, it has been suggested that females perform better on delayed-response problems because they are less distractible than males; this may offer some explanation for the gender differences observed (Fletcher, 1965). It would be interesting to consider responsiveness to gaze cues as a function of social status in other contexts. Whereas previous research has underlined the importance of the attentional structure of groups (Chance, 1967; Watts, 1998), there may also be some relationship between gaze monitoring and social hierarchy (see Blois-Heulin & Girona, 1999, for patterns and targets of looking relative to rank in a species of Old World monkey). Lower ranking individuals may gauge the visual orientation of dominants and thus assess the risk of approaching desirable social partners or food items, for example (Hare et al., 2000).

The results of this study converge with those obtained using a standard object-choice approach in that the baboons responded more readily to head orientation than to eye direction alone (Anderson et al., 1996; Itakura & Anderson, 1996; Peignot & Anderson, 1999). Furthermore, during supplementary testing with Ida using a combination of head and eyes cues, she preferentially responded to head direction when it conflicted with eye gaze, as also demonstrated in capuchin monkeys performing the object-choice task (Vick & Anderson, 2000). It is possible that monkeys simply learn to respond to arbitrary cues to solve the problem presented (Povinelli & Giambrone, 2000). That is, they learn head or eye direction as a cue to respond to the appropriate side without any appreciation that these are indicators of another's visual orientation per se (Tomasello, Call, & Hare, 1998); as head direction is a more obvious cue, this association may be more readily learned. Alternatively, the advantage for head over eye direction cues may reflect an underlying tendency to attend to this form of cue. For many of species of nonhuman primates, head orientation may be a reliable signal of another individual's visual orientation (see Kobayashi & Kohshima, 1997, 2001).

Whatever the reason underlying the greater salience of head orientation as a cue, it is important to note that the baboons did not demonstrate an appreciation of the actual focus of the experimenter's gaze. A similar finding has been reported in chimpanzees (Povinelli et al., 1999). Although these results may offer little support for the view that the baboons were accurately adopting the visual perspective of the experimenter in the competitive task, it is also possible that their responses were simply tempered by their experimental experience. A different experimental design, with nonattended trials integrated from the onset of testing, might be illuminating (e.g., Povinelli et al., 1999). Also, examining whether monkeys are able to accurately detect the targets of another's gaze and ignore distractor objects, as has been shown in chimpanzees, would be informative (Tomasello et al., 1999), as would attempting to distinguish between location-based responding (i.e. gaze following) and object-based responding, which would be indicative of joint visual attention (Moore & Dunham, 1995). Specifically, moving previously attended objects to a new location prior to the subject's response might indicate the level at which gaze behaviors are processed.

Although the baboons learned to use gaze cues to perform the competitive task without explicit training, it is difficult to ascertain which features of these experiments were conducive to effective cue exploitation. Possibly, the competitive paradigm is more suited to revealing gaze reading than the more frequently used object-choice paradigm (Hare, 2001), but the results of Experiment 2 suggest that the use of screens and containers, both integral aspects in the object-choice task, may also hinder cue reading. In other words, it could be that the modified task simply had fewer sources of information (such as objects) to be processed to solve a discrimination task (see Hare et al., 2000; Povinelli & Giambrone, 2000). Counterbalancing the order of presentation of an objects and no objects condition within the competitive paradigm might help to clarify this issue.

In conclusion, the object-choice paradigm may not be the most appropriate means of assessing nonhuman primates' abilities to assess the visual coorientation of other individuals. Performance on the object-choice task does not stem directly from a tendency to coorient with others. Although monkeys readily coorient with other individuals (Anderson & Mitchell, 1999; Emery et al., 1997; Ferrari et al., 2000; Tomasello et al., 2001), they may require explicit training to master tasks that could be performed on the basis of coorientation. The present study has identified features of the object-choice task that may hinder effective cue reading: The use of objects and a screen disrupted the performance of baboons already experienced at using experimenter-given cues to solve a task, and the presentation of static cues may also impede performance. Although it is difficult to draw conclusions regarding the importance of the competitive rather than cooperative nature of the task used here, the baboons learned to make use of experimenter-given cues in competition without the need for explicit training, and 1 individual did so fairly quickly. Finally, unlike the object-choice task, the competitive task could not be solved on the basis of a direct coorienting response. That is, any learned or reflexive tendency to coorient with other individuals would not have directly facilitated performance in this competitive task. Thus, further exploration using complementary approaches to studying gaze-monitoring abilities in nonhuman primates are required before strong conclusions regarding comparative abilities may be drawn.

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