Use of Experimenter-Given Cues in Visual Co-Orienting and in an Object-Choice Task

by a New World Monkey Species, Cotton Top Tamarins (*Saguinus oedipus*)

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Abstract

Two different methods assessed the use of experimenter-given directional cues by a new world monkey species, cotton top tamarins. Experiment One used experimenter-given cues to elicit visual co-orienting toward distal objects. Experiment Two used experimenter-given cues to generate accurate choices in an object choice task. While there were strong positive correlations between monkey pairs to co-orient, visual co-orienting with a human experimenter occurred at a very low frequency to distal objects. Human hand pointing cues generated more visual co-orienting than did eye gaze with or without head and body orientation. Significant accurate choices of baited cups occurred with human point/tap cues, and human look cues, where looks involved head and body orientation as well as eye gaze. The results highlighted the importance of head/body orientation to induce shared attention in cotton top tamarins, both in a task that involved food-getting and a task that did not.

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A contemporary empirical question in primate research is to determine the extent to which primates understand that there is informational value in following another animal's direction of gaze. In humans, the cognitive precursors to learning human language include following the spatial signaling function of a gaze, directing attention toward postures of the head and the hand of another, and finally, associating a symbol to label the object of gaze or gesture. The ability to look where someone else is looking, called joint visual attention in the developmental literature (Butterworth, 1995), occurs in human infants at 2 months of age (Scaife and Bruner, 1975). Between 9 months and 15 months of age, human infants show increased joint attention engagement, increased gaze and point following, imitation, and early language production (Carpenter, Nagell, & Tomasello, 1998). By 14 months of age, humans show the ability to manipulate another's direction of gaze by gaining the visual attention of another and then redirecting it to distal objects (Adamson & Bakeman, 1991; Butterworth, 1998). A recent longitudinal study of 20-month old human children indicated that the incidence of their gaze switches between an adult and an active toy, and their rate of looking to an adult in an ambiguous goal-directed task was associated with their displayed "theory of mind" abilities at 44 months (Charman et al., 2001). Clearly the ability to hold joint attention and to use gaze direction to share and gather information contributes to social-cognitive development, including language learning and concepts such as others' minds.

The most conservative statement one could make regarding whether primates generally follow another's direction of gaze is that most can follow a human's signals

when they consist of changes in head and body orientation (i.e., Anderson & Mitchell, 1999; Itakura, 1996; Povinelli & Eddy, 1996; Tomasello, Call & Hare, 1998). Still, published results highlight differences among different groups of primates to follow experimenter cues. One study indicated that prosimians, specifically lemurs, could not reliably follow the eye gaze of an experimenter, and thus failed to visually co-orient, while some old world monkeys (i.e., macaques) reliably followed the eye gaze of an experimenter (Anderson & Mitchell, 1999). The macaques' ability to follow eye gaze coincident with head orientation was also found by Emery, Lorincz, Perret, Oram & Baker (1997) using conspecifics to direct attention.

Capuchins, the only new world monkey species studied, has been tested in object-choice tasks that involved obtaining food reward and that involved human experimenters directing the choice. One capuchin was able to be trained to use experimenter-given cues of head and eye gaze, but could not follow eye gaze alone (Itakura and Anderson, 1996). Vick and Anderson (2000) trained 3 capuchins to use pointing cues and eye gaze-with-head cues to make correct choices in an object-choice task. Still, the head and eye combined cue carried the highest percent correct score, and none of the subjects tested made significantly accurate choices when eyes alone were the cue.

Apes including chimpanzees, orangutans, and humans (Itakura & Tanaka, 1998) seem to be able to attend to a location that is indicated by eye gaze with head orientation, an eye glance without corresponding head orientation, or the hand pointing of an experimenter, and they do so without training. Still the ape data are somewhat controversial; for example, Povinelli, Bierschwale & Cech (1999) found the act of visually co-orienting with a glance in chimpanzees not to be present in juveniles, and that

head orientation seemed to be of more prominent use than eye orientation in

chimpanzees. Peignot & Anderson (1999) found that gorillas were able to make correct

choices in an object-choice task when the correct location was indicated by pointing or by

combined head and eye gaze cues, but not with a glance without corresponding head

orientation. And the orangutan in the study conducted by Itakura and Tanaka (1998) had

been a performing orangutan with one experimenter, his trainer. It is possible that the

spontaneous occurrence of following a glance in that case was an outcome of more

social-cognitive enculturation experiences for that animal, and not a general outcome of a

member of that species.

A particular conflict in assessing co-orientation in many studies is whether one

should expect a monkey or ape to co-orient coincident with the direction of a human

experimenter's gaze, especially when the experimenter (and perhaps the stimuli to which

the experimenter attends) is not relevant to the species' natural world. Engaging a

conspecific in the directional cue, as was done by Emery et al. (1997) seems more

biologically salient and thus a more valid test of the animals' ability. Still it is difficult in

many experimental situations to train a conspecific to direct the attention of others.

Moreover, if one gets the attention of a single animal by using a relevant stimulus like

food (as in Emery et al., 1997), it is difficult to discern whether, when others also follow

the look, they are looking in that direction because another animal looked in that

direction, or because they too noticed the food stimulus independently.

When confined to a comparison of studies using a human experimenter to guide

orienting or choosing, one species of prosimian seems incapable of sharing the visual

space of a human, at least in a test in which the response is to visually attend in the

direction of the experimenter's gaze. Capuchins, the tested new world monkey species, do not automatically make correct choices in an object choice task with experimenter-given cues, and thus do not naturally understand another's visual perspective even in a condition that provides motivation (in the form of food reward) for doing so. Capuchins can be trained to make correct choices with human eye gaze combined with head orientation cues, and thus can learn to use these cues to gain information about food locations. The old world monkey species macaques and various apes tested, including orangutans, chimpanzees, gorillas, and humans follow eye-head cues and pointing to visually co-orient in correspondence with an experimenter's gaze. Still, a glance alone, or eye orientation without any other body or head orientation, does not consistently direct the attention of gorillas nor of chimpanzees.

These experimental data stand in stark contrast to the clear importance to primates of the face (including eyes) in recognizing individuals (Parr, Winslow, Hopkins, & de Waal, 2000) and to the finding that there are brain regions in monkeys whose cells show specificity to the processing of information about gaze, including both head orientation and eye direction (Perrett, Smith, Potter, Mistlin, Head, Milner, & Jeeves, 1985). A recent study of rhesus monkeys indicated that they gaze more often at the eyes of a human head stimulus than any other facial area, especially when the eye gaze of the stimulus was directed at them (Sato & Nakamura, 2001). Taken together, these studies confirm the salience of eyes, head, and of directed gazes in primates, but they deduce little about the ways in which primates can use such information. .

The current set of studies employed two different methods to test a new world monkey species, cotton top tamarins *(Saguinus oedipus)*. Eye gaze with head orientation,

a glance without head or body orientation, and pointing, were assessed as informative directional cues. In the first study, various directional cues were used to test whether the subjects would visually co-orient toward distal objects indicated by experimenter-given cues. This method replicates the work by Anderson and Mitchell (1999) with a prosimian and old world monkey species and tests the ability of new world monkeys to co-orient with human experimenters. In this application, a distal stimulus was used to make the co-orienting a bit more motivated, but food was not used as part of the motivation to direct gaze so that no learning by reinforcement was in effect. In the second study, the same directional cues, and tapping with pointing, were used to test whether individuals of the species could accurately select a target in an object-choice task with food, the obtained reward. The goal was to test a different new world monkey species to contribute to the evidence of the abilities of new world monkeys to naturally understand the information conveyed in a directional cue. It was also important to determine, without explicit training, whether eye gaze could direct a subject's attention to a novel object, and to a baited object, and whether the use of various directional cues (i.e., pointing, gaze, or glance) were differentially used by the subjects in the different tasks. For example, since members of this species are not active food sharers, placing a hand near baited objects could lead to an avoidance of the object closest to the hand on the part of the subject, thereby leading to consistent inaccurate selection of an object to avoid confrontations over a single location of food. Eye gaze may be just as informative but less intrusive in the object choice task. Conversely, hand or body proximity may be a useful guide to attending in the visual co-orienting task in which novel objects are placed at some distance. Greater distance and lack of information about the relevance of said objects may

lead subjects to utilize body orientation and body cues as the strongest index of the direction to which they should attend.

Experiment One: Visual Co-Orienting Toward Distal Objects

In this study, two different objects were placed on opposite sides of a subject's cage, and then an experimenter directed his/her attention toward one of the two objects by pointing at it, gazing at it with head and body oriented toward it, or "head gazing" at it with coincident head orientation without body orientation. The data of interest were the absolute frequencies with which cotton top tamarins visually co-oriented with the experimenter, to compare results with those collected by Anderson and Mitchell (1999) for macaques and lemurs.

Methods

Participants

A group of 6 cotton top tamarins (*Saguinus oedipus*) served as participants. The animals were socially housed as 3 pairs, and studied as pairs in their home cages. There were a total of 2 females and 4 males in the study with adults and young adults/juveniles included. The adults included females Oprah (age 12) and Fozzy (age 6) and males Mac (age 10) and Zhivago (age 6). Young adults included in the study were 2 males Rolo (age 3) and Yohoo (age 2). All participants had been nursery-peer reared in lab settings, and had been socially housed, since December, 1998 as nonbreeding couples (Oprah and Mac, and Fozzy and Zhivago), and as brothers (Rolo and Yohoo).

The pairs were housed in three 0.85 m width X 1.5 m height X 2.3 m length cages located in the animal colony facility. The pair cages were visually separated by opaque sheets. The subjects were on a twelve hour light/dark cycle and had free access

to water. All animals were maintained on a complete diet consisting of a yogurt &

applesauce breakfast, a lunch of Zupreem Marmoset chow, Mazuri New World Monkey

dry chow, fruits and vegetables, and a protein snack (e.g., eggs, hamburger, mealworms)

daily.

Stimuli

For each session, two different stimuli were positioned 35 cm from the front of

the subjects' cage on each of the two long sides of each cage. Each stimulus on each side

was placed approximately 7.5 to 15 cm from the cage front panel and fixed on the wall or

sheet on each side (left and right) of the cage. The bottom of each stimulus was 147.5 cm

from the floor. The pairs of stimuli were different for each session and consisted of color

photos of flowers (30 cm X 30 cm), black and white pictures of dogs (35 cm X 28.75

cm), or colorful pictures from a children's book (45 cm X 27.5 cm). The stimuli were all

novel to the tamarins' environment, and were selected to be bright, detailed and engaging.

Apparatus

A Canon VC-C3 digital camera was placed on a cart 120 cm from the floor and

45 cm away from the cage. It was placed beneath one of the stimuli. The camera was

placed so that it could view one of the stimulus locations. The camera subtended a

recording visual angle of 76.8 degrees horizontally. The camera view was moved as little

as possible. It was connected to a Sony LCD monitor for immediate viewing by the

experimenter controlling the camera and to a Sony SLV-678 VCR for recording of the

behavior of the pair during each session.

Procedure

Four researchers conducted the study, with one operating the camera and the other three serving as the indicating stimulus, with two different researchers serving this purpose during the experiment consistently for each pair, and a novel researcher introduced for a brief test of all pairs of subjects at the end of the experiment. The camera operating experimenter positioned himself near the camera, monitor and cart. When the pair of subjects were in view by the camera and were stationary for a minimum of 2 seconds, timed by a handheld stopwatch, the recording experimenter started recording and instructed the indicating experimenter to begin the trial. The indicating experimenter was always positioned at a neutral starting position, either 65 cm (close) or 115 cm (far) from the front of the cage and centered 150 cm from each of the stimuli. Once cued, the indicating experimenter performed the orientation behavior appropriate for that trial for ten seconds and then returned to the neutral position. For an additional ten seconds, the indicating experimenter faced straight ahead at the neutral position. Thus each trial lasted 20 seconds total. There was a 5-second intertrial interval (ITI) inserted between trials, and the recording experimenter recorded with the camera off during the ITI's to visually separate the trials for later coding. There were 7 different trial types in the experiment. The trial types were presented in pseudo-random order, with the presumption that equal numbers of trial types were shown each session and no more than three of any type of trial was given consecutively. Exactly 8 of each trial type for each cage side (left or right) were scheduled for the experiment, for a total of 112 trials across all sessions. The number of trials presented per session varied from 42 to 6, depending upon the subjects' behavior to start each trial (defined above as in view by the camera, and stationary for 2

seconds preceding each trial), and depending upon the number of required trials left to

test each trial type consistently across the sessions. The trial types are described below.

Close Point: The indicating experimenter walked from the close neutral starting

position toward the stimulus while pointing to it with an index finger. He or she moved

as close as possible without being in the camera's view, until he/she was 75 cm away

from the stimulus, with his or her finger approximately 27.5 cm away. At the end of 10

seconds of pointing, he or she returned to the neutral position.

Close Look: The indicating experimenter walked from the close neutral starting

position toward the stimulus while looking directly at it, with the body oriented towards

the stimulus. He or she stopped 75 cm away from the stimulus and remained engaged

and staring for the remaining 10 seconds before returning to the neutral position.

Close Head Gaze: The indicating experimenter walked from the close neutral

starting position toward the stimulus while looking directly at it, with his or her head and

eyes oriented to the stimulus. The body was not oriented towards the stimulus. The

indicating experimenter stopped 75 cm away from the stimulus and remained engaged

and staring for the remaining 10 seconds before returning to the neutral position.

Far Point: The pointing experimenter remained at the far neutral starting position

for the whole trial. He or she looked directly at the stimulus, leaned towards it, with the

body oriented towards the stimulus and pointed with the index finger. After 10 seconds,

the indicating experimenter remained in the far neutral position but faced straight ahead.

Far Look: The indicating experimenter remained at the far neutral starting

position for the whole trial. He or she looked directly at the stimulus, leaned towards it,

with the body oriented towards the stimulus, but did not point at it. After 10 seconds, the indicating experimenter remained in the neutral position but faced straight ahead.

Far Head Gaze: The indicating experimenter remained at the far neutral starting position for the whole trial, but on this trial, he or she looked directly at the stimulus, with only the head and eyes oriented towards it. The indicating experimenter oriented the body away from the stimulus. After 10 seconds, he or she remained in the neutral position but faced straight ahead.

Catch Trial: The indicating experimenter walked from the close neutral starting position toward one of the stimuli to a distance of approximately 35 cm, but never looked at or faced it with his or her body. The indicating experimenter waved and made noise to get the tamarins' attention for 10 seconds. After 10 seconds, he or she returned to the neutral position and looked straight ahead. The point of the catch trial was to compare the rate of getting attention when attention was not directed toward the stimulus, but a human was still engaged in movement to the test locations around the cage.

Test with Novel Indicating Experimenter

A final set of 42 trials, 3 of each trial type towad each side stimulus (left and right), was presented to each pair, and in this final set, a novel experimenter was used as the indicating experimenter. This test was administered to determine if the subjects' looking behavior to various directional cues generalized to different people. All of the same conditions were employed, with the exception that the indicating experimenter was replaced.

Behavior Coding

Two undergraduate students coded behaviors from the videotapes of sessions. The coders were blind to the trial order, the side of the cage on which the indicating experimenter directed the tamarins' attention, and the type of trial (point, look, glance, or catch) that was being presented. Each coder determined the number of looks to each stimulus, defined as the tamarin's head or head and body oriented toward one of the stimuli, during the first 8 seconds of each trial. The coders also counted the number of "neutral" looks, or head or head and body orientation toward the neutral starting position for each trial. A look was considered initiated when the subject directed its head or head and body in that direction. A single look was ceased when the subject disengaged from that orientation. For each trial, a number of looks to each stimulus and to the neutral position were possible, thus chance level responding was not 1 of 3 or 33% of any type of look. Looks that occurred by either subject in the pair under study were counted, and a total number of looks in each of the three directions was calculated for each trial for the pair. While direction of looks was coded with a high degree of reliability (see results), the identification of individuals had not been possible with confidence from a training tape viewed by the coders. Thus the coders were required to count total looks from both subjects for each trial, and not to identify individual looks by subject's identity. Finally, if both subjects were out of the camera's view or blocked from sight for the full 8 seconds, the trial was recorded as not possible to code.

Independently, one experimenter coded the number of times per trial that each of a pair of animals looked in the same direction that the other animal looked. The look behavior was defined as before (head or head and body oriented in a direction). This

coding was done independently of any knowledge of the kind of trial being presented,

and was coded without the knowledge of the direction of the orienting of the indicating

experimenter for each trial.

Results

Each pair of subjects was exposed to a total of 112 trials, or approximately 8

examples on each side of the cage (right, left), of each of the 7 trial types, including

pointing, looking, and glancing at a close distance from the stimulus; pointing, looking,

and glancing at a far distance from the stimulus; and a catch trial type in which the

experimenter simply moved to the location of the stimulus. Mac and Oprah's data were

based on110 trials, because in 2 trials the experimenter could be seen in the videotape and

these were edited from the tape before coding took place.

The videotape was coded for instances in which the second monkey of each pair

looked in the same direction that the first monkey looked per trial. The total number of

looks that involved co-orienting between pairs (either towards or away from the stimulus)

for each session were subjected to a Spearman's rho correlational analysis. The

correlations between pairs were compared to correlations between pseudo-pairs, or

random pairs of animals who did not reside in the same cage. The correlations for the

caged pairs were all significant and positive (Mac and Oprah, ρ = +.909; Rolo and

Yohoo, ρ = +.775; Fozzie and Zhivago, ρ = +.773, all significant at $p < 0.01$). Of the 12

correlations for all possible pseudopairs, eight were negative, ranging from -0.399 (Mac

with Yohoo) to -.682 (Mac with Zhivago) and 3 were significant negative correlations

(between Mac and Fozzie, ρ = -.597, p =.02; Mac and Zhivago, ρ = -.682, p=.005; and

Oprah and Zhivago, ρ =-.565, p=.03). Four correlations were low and positive, with a

range of +0.331 (for Rolo and Fozzie) to+ 0.417 (for Rolo and Zhivago). In general the

pairs that resided together showed highly significant positively correlated co-orienting,

whereas any two randomly selected animals showed relatively low positive, low

negative, or in a few rare cases, significant negative correlations.

To discern the rate of visual co-orienting with the human experimenter, a χ^2

analysis was performed on the absolute frequency of visually co-orienting (or VCO's) per

pair, determined as the number of looks in the direction of experimenter-given cues, as

compared to the absolute frequencies of no visual co-orienting (or no-VCO's), calculated

as the sum of all visual opposite responses, and visual neutral responses per pair for all

trials in the experiment. The data were coded for total looks (left, right, and neutral) for

each trial for each pair. A total amount of looks of each type were summed for each trial

for each pair of subjects throughout the experiment, chiefly because the subjects seemed

to co-orient together and so the measure of looking seemed to co-depend on both

animals. Interobserver agreement was tested by comparing another coder's judgments of

the frequency of left, right, and neutral looks for 1 session for each pair. The percentage

agreement per session ranged from 89% for Rolo and Yohoo, 71% for Fozzy and

Zhivago, and 80% for Mac and Oprah, with an overall correlation of r=+0.4969 for the

data from all 3 sessions compared across the two raters (F(1,7)=2.29, p=0.17). One rater's

data were used in all the analyses shown below.

The subjects co-oriented with the human experimenter on average on all direction

cue trials 26.98% of the time. Table 1 presents the results of χ^2 analyses of absolute

frequencies for the two groups of animals from Anderson and Mitchell (1999), and the

group of tamarins in this study. It is clear that while the macaques showed more VCO's

than not (χ^2 (1) (N=5) = 79.49, p < 0.0001), the lemurs showed less VCO's from the prior

study (χ^2 (1) (N=4) = 51.49, p < 0.0001). These results are in agreement with the

individual binomial tests conducted by Anderson and Mitchell (1999). The tamarins

studied here also showed less VCO's with the experimenter (χ^2 (1) (N=3 pairs) = 123.41

for all visual and pointing indications, χ^2 (1) (N=3 pairs) = 18.58 for looking trials that

were similar in method to Anderson and Mitchell). This pattern was evident in the

tamarin data collapsed across all direction cue trials, the data from look indicator trials

alone, and for more individual groupings of each pair of subjects (see Table 1 for

individual pair results).

Finally, percent correct scores for visual co-orienting were calculated for each

pair by dividing the total VCO responses by the sum of VCO and no-VCO responses that

occurred to a particular indicator type (i.e., far point, far look, far head gaze, close point,

close look, and close head gaze trials). A Friedman's ANOVA for nonparametric,

repeated measures data was used to determine if there were significant differences in

accurate visual co-orienting between these 6 trial types within each pair of subjects. Since

the current methodology used hand pointing and head gazing without body orientation as

well as a direct look (with coincident head and body orientation) by the experimenter,

and two distances were employed, it was important to determine if this species was more

ready to co-orient with particular cues.

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The Friedman's ANOVA resulted in a trend (χ^2 (5) =9.9048, p = 0.078) in the

accuracy of looking between the 6 relevant trial types (see Figure 1 for medians per trial

type). Pairwise comparisons between the 6 trial types were not indicated because the

overall result was a trend. Wilcoxon matched pairs signed-ranks tests were used to

compare two variables overall: distance (close vs. far), and type of indicator (point, look,

or head gaze). The comparison of accurate co-orienting between close cues and far cues

was significant (p=0.05, estimated Z = 1.955), indicating that there were significantly

more accurate scores for close indicators (median = 27.55%) then for far indicators

(24.16%). Moreover, there was a significant difference between accurate co-orienting

when hand pointing was used (median = 29.61%) than when look indicators were used

(median = 25.89% for looking, estimated Z=1.99, p = 0.046). The VCO accuracy

following hand pointing was also significantly higher than accuracy when head gaze

indicators were used (median = 22.06% for glancing, estimated Z=1.99, p = 0.046).

Accurate co-orienting was not differentiated between look or head gaze indicators.

The final test session consisting of 42 total trials for each pair with a novel

indicating experimenter yielded similar but statistically weaker results. The tamarins'

absolute frequencies of VCO's (58) and no VCO's (182) indicated an overall rate of

24.17% VCO's across trials, as compared to an overall rate of 26.98% VCO's when each

pair was exposed to 112 trials with the original indicating experimenter. In the new test,

the VCO frequencies were significantly lower than an equal distribution (χ^2 (1)

(N=6)=64.01, p < 0.0001 for all subjects), indicating that there was not consistent visual

co-orienting with the new indicating stimulus. A Friedman repeated measures ANOVA

of the 6 relevant trial types on the test data showed a nonsignificant pattern of results (χ^2

(5)=4.71, p = 0.45). In Wilcoxon matched-pairs signed ranks tests of the variables

close/far and point/look/head gaze, no significant differences were found. However, a

trend emerged revealing a similar pattern that pointing generating more VCO's (median =

34.85% for pointing) than looking (median = 22.13% for looking, estimated Z = 1.78, p =

0.07), and more than head gazing (median = 21.52%, estimated Z = 1.57, p = 0.116).

Discussion

Tamarins looked in the appropriate direction significantly less frequently in

correspondence with an experimenter's gaze or point, thus tamarins appear not to visually

co-orient with humans. Still, the correlational analyses indicated that tamarin caged pairs

co-orient at impressive rates with each other. The published literature has indicated that

when humans cue the direction of looking, macaques, chimpanzees, orangutans and

human infants can visually co-orient consistently and with high frequency, while lemurs,

the only prosimian tested, cannot (Anderson & Mitchell, 1999). Tamarins did not show

the capacity to collect data naturally from a human's visual perspective, but showed a

high degree of co-orienting with cage mates.

The indicator trial type analyses suggested that tamarins' attention was drawn

when a human's body approached a novel stimulus. A hand pointing indicator generated

significantly more visual co-orienting than did a look indicator or a head gaze indicator,

and body nearness (close cues) generated more co-orienting. When interpreting the

meaning of the result that pointing cues were more successful at generating visual co-

orienting, it is important to note that these tamarins had never been observed to use any

pointing to indicate location to each other. One experimenter had used pointing to try to

direct the monkeys into a transport cage in the past, but had met with little success. Thus,

it is assumed that pointing was a more successful cue not because the tamarins took

pointing to mean that they should follow the direction of the point, but rather that

pointing meant a body part was a bit closer to an interesting feature in the room. In sum,

the tamarins' attention was drawn to the body location of others when others approached

novel stimuli, and to the nearness of another's body to novel stimuli, and especially to the

nearness of another's hand to novel stimuli. Gaze direction, looking, and head orientation

were not satisfactory cues to induce co-orienting in tamarins.

Experiment Two: Experimenter-Given Cues in an Object Choice Task

In this task, one of two cups was baited with a food reinforcer in such a way that

the subjects could not determine which one was the correct cup. Then, the experimenter

presented the cups and indicated the correct choice by a cue of pointing and tapping,

pointing, looking, or glancing at the baited cup. Choice accuracy significantly above 50%

or chance level responding would indicate that the subjects gained information from the

experimenter-given cues to make a correct choice. Catch trials were included that

employed an experimenter-given "look" cue but did not yield food reinforcement at all,

or did not offer it in the indicated location. The catch trials made the look cues generally

less useful, for on 67% of look trials, no reinforcement could be obtained for correct

choices. This task tested the ability of cotton top tamarins to use experimenter-given

cues to maximize the chances of obtaining food reinforcement. Capuchins, the only other

new world monkey tested in this way, did not spontaneously use such cues to make

correct choices, but could be trained to use some directional cues to improve accuracy in

the object-choice task.

Method

<u>Participants</u>

A total of 6 cotton top tamarins (<u>Saguinus oedipus</u>) who were not in Experiment One served as participants. The animals were socially housed as a family of 6, and consisted of females Caitlin (age 11), Ophelia (age 5), Olympia, (age 2) and Viola (age 1), and males Dante (aged 2) and Sebastian (age 1). All participants had been nursery-peer reared in lab settings, and had always been socially housed as a family group.

The family lived in a cage 1.8 X 3.0 X 2.3 m in size. The subjects were on a twelve hour light/dark cycle and had free access to water. All animals were maintained on a complete diet consisting of a yogurt & applesauce breakfast, a lunch of Zupreem Marmoset chow, Mazuri New World Monkey dry chow, fruits and vegetables, and a protein snack (e.g., eggs, hamburger, mealworms) daily.   The subjects had participated in an experiment involving a mirror, and had been exposed to videotaped images of cotton top tamarins and still photographs of cotton top tamarins and of buildings. No prior study had used experimenter-given cues to direct attention, or to indicate correct choice in a task.

<u>Apparatus</u>

Two transparent cups, measuring 7 cm in height with an 8.89 cm opening, and two opaque cups, measuring 9.3 cm in height with an 8.7 cm opening, were used in an inverted orientation in training and testing. The cups were placed on a cart (1.17 m height, 0.4 X 0.5 m top) separated such that the distance center to center was 11.43 cm. For both sets of cups, holes measuring 3.81 cm X 3.81 cm were made along one side of the opening of each cup, and then covered with 2 layers of opaque cloth with vertical slits cut in it. When each pair of cups was used, each cup was taped to the cart such that the covered openings faced the subjects, and so that the subjects had to flip the cups back toward the experimenter to receive a food reward. Food rewards consisted of individual

pieces of fruit sugar cereal, mealworms, or dried fruit, and the rewards were varied throughout training and testing. A 3-sided box measuring 14.8 cm height, 21 cm length and 29.6 cm width was used to cover both cups between trials. The open side of the box faced the experimenter and was covered with a thick opaque cloth. The experimenter sat behind the cart throughout each session. Trials were recorded using a Canon VC-C3 digital camera which was positioned behind the experimenter and was focussed on the cart and the subject's choices. The camera was connected to a Sony SLV-678 VCR in a laboratory where trials were videotaped.

Procedure

The procedure consisted of a training phase, in which the animals were trained to tip over cups for reinforcement, and a test phase, in which animals were given indicator cues to identify the baited cup and their choices were recorded.

Training

In the training phase, no indicator cues were given. Both cups were always baited with food. A shaping process ensued whereby the experimenter exposed the subjects to the apparatus in a stepwise fashion, moving forward only when > 50% of the subjects had found food reinforcement and eaten it. First, the experimenter placed food liberally on the cart and waited for subjects to sit on the cart to forage for food. Next food was only placed in front of two inverted transparent cups, taped to the cart. Once more than 50% of the subjects had obtained food in front of the cups, food rewards were placed under both transparent cups, with the holes cut in the cups uncovered. Once criterion was met, transparent cups were used, but there were no holes cut out for subjects to reach through. This change demanded that subjects tip over the cups to obtain food rewards. Next, opaque cups with open holes were used, with food baited in both. Once more than 50% of the subjects had obtained food from them, the holes were covered with cloth. The final step was to expose the subjects to a set of trials that consisted of using the cardboard box to cover the cups, baiting both cups, uncovering the cups to allow for choices, and then

covering the cups again. Once more than 50% of the subjects had acquired food from the opaque cups in this trial-like progression, the test phase began.

Test

Test sessions consisted of 24 trials in which each of 6 indicator cues was used 4 times each, twice on each side (e.g., left and right sides). Each trial lasted 60 seconds maximum, or it was aborted if a subject had not made a choice within 60 seconds. A 30-second intertrial interval (ITI) was imposed, during which time an experimenter baited one of the two inverted opaque cups with food reward. Occasionally, 2 blocks of 24 trials were conducted on a single day, if subjects seemed very responsive. Sessions typically lasted 30 minutes. All subjects were present during testing, and could observe each other respond and obtain food. This natural setting produced a few subjects (the mother of the group, and the oldest male) as the most frequent responders. Two younger female siblings also responded on a sufficient number of trials to be included. The two youngest members of the family (Sebastian and Viola) were not permitted to participate by active blocking by the other family members. Thus only 4 subjects were tested.

Each trial began with an intertrial interval, during which time the cups, taped to the cart, were covered with a cardboard box. An experimenter baited one of the two cups according to a schedule which randomized left and right-side baitings to occur equally over the 24 trials, with the constraint that neither side was baited more than 3 times consecutively. The experimenter was careful to touch both cups, not just the one being baited. He or she also made certain that, on some baitings, the correct cup was the last one touched, and on some, the incorrect cup was touched last. During the baiting, the open side of the box was employed by the experimenter to touch cups and bait, but the baiting process was concealed with an opaque cloth. If subjects tried to position themselves to observe the experimenter during the baiting process, the experimenter used vocal commands and hand approaches to move them away from the baiting area.

Once a cup was baited, the box was lifted to reveal both cups simultaneously, and the trial began. The experimenter immediately indicated the correct baited cup with one of the following indicator cues, also pseudo-randomized throughout the session with the constraint that no more than 3 trial types could occur consecutively:

Point/Tap: The experimenter gently tapped the top of the correct cup with one finger repeatedly, pausing between groups of 4 taps to move his or her hand up approximately 5 cm above the cup, while pointing to the correct cup with the tapping finger. His or her body, head and eyes were also oriented toward the correct cup.

Point: The experimenter pointed to the cup with one or two fingers hovering 5 cm above the correct cup. His or her body, head and eyes were also oriented toward the correct cup.

Look: The experimenter oriented his or her body, head, and eyes toward the correct cup. The experimenter's head was moved approximately 17 cm above the cup.

Glance: The experimenter oriented his or her eyes toward the correct cup. The experimenter's head and body were oriented straight ahead, and not in either cup's direction.

There were two trials that employed a "look" cue that were meant to test the subjects without the use of reinforcement. These cues were used with equal frequency as the other more meaningful indicator cues. They were:

No Reinforcement Look : The experimenter gave the look cue, but neither cup was baited with food.

Opposite Cup Look: The experimenter gave the look cue to the incorrect cup; the cup not indicated was the one that was baited.

During each trial, subjects were free to participate. Only the first volunteer's first choice was accepted as a choice. A choice was defined as the subject touching the cup. The cup was typically knocked over by the subject, but in the event this did not happen, the experimenter would tip over the cup that was first touched by the subject, revealing

either a) nothing, or b) food reward, if it was the "correct" cup. Immediately following the participating subject's response, and, if the choice was correct, the obtaining of the food reinforcement, the cardboard box was placed over both cups, and the intertrial interval period began.

Two experimenters were present during all sessions. One recorded the subject's identity and choice for each trial, while the other served as the indicating stimulus. The experimenters alternated roles over sessions. Each session was also videotaped, for later verification of subject identity, if it was needed.

Results

The training period was conducted for 7 sessions, and the test was conducted for 10 sessions over a 3-week period of time. Only 4 of the 6 subjects participated in the task with any consistency during that time, thus their data were used in the analysis. The other two subjects were the younger twin members of the family, and participated in fewer than 10 total trials, with uneven exposure to the various indicating cues. In some cases, the younger subjects only responded to a single trial with a particular cue. They were dropped from further analysis. The subjects whose data were used participated in at least 30 trials in the test, with at least 5 exposures to each trial type. Participation rate was 118 trials for Caitlin, the mother of the family unit; 160 trials for Dante, the oldest male sibling in the family; 32 for Ophelia, the oldest female sibling in the family; and 30 trials for Olympia, a middle female sibling.

One concern about participation was that subjects might have learned by reinforcement to make particular kinds of choices with particular cues. A test of whether acquisition of correct responses transpired was conducted by a best-fitting line analysis over chronological blocks of 10 trials for each subject. Figure 2 shows the percent correct scores per subject per 10-trial block throughout the experiment. Two characteristics were clear in these data: 1) subjects varied in accuracies from the start of the experiment, with three subjects showing accurate performance from the first few blocks of 10 trials while

the fourth showed chance level performance within the first few blocks of 10 trials, and

2) accuracies for most of the subjects did not steadily increase with exposure within the

set used in Experiment 2. A regression analysis found the best fitting line for Caitlin to be

a linear increasing function (y=36.18 +2.91x; r^2 = 0.32). For Dante, Ophelia, and

Olympia, the best fitting functions were either negative linear functions (Ophelia,

y=1/(0.0099+0.0029x, r^2 = 0.53), a negative reciprocal function (Dante, y=55.44 +15.68

/ x, r^2 =0.05) or a flat function (Olympia, y=60+0x, all variance accounted for). Thus

Caitlin's scores appeared to increase slowly by approximately 3 percentage points per 10-

trial block, while the other three subjects' scores remained relatively stable or showed

very slight decreasing functions.

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Insert Figure 2 about here

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Averaged percent correct scores for the participating subjects for each of the four

indicator cue trial types are presented in Figure 3. Wilcoxon one-sample tests were

conducted to compare each set of scores for each trial type against a hypothetical mean of

50%, or chance level responding. It was hypothesized that, if subjects used the

information in the cues to make choices, their accuracy with those cues should be

significantly greater than 50%. There was a trend for trials using Point/Tap cues which

generated more accurate selection of the target (median for point/tap = 60, estimated Z =

-1.83, p = 0.067). Trials using Look cues generated a similar trend in that percent

correct scores were also higher than 50% or chance level accuracy (median for look =

74.17, estimated Z = -1.83, p = 0.067). The trend that emerged for look cues is especially

important since 67% of the look cue trials delivered no reinforcement for correct choices.

In other words, even though ineffective at predicting the availability of reward, the look

cues generated the most accurate selection of the cued target.

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Insert Figure 3 about here

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Trials using pointing cues (median = 58.33) or glance cues (median = 51.58) did not generate accurate choices above 50% or chance level. A nonparametric Friedman's repeated measures ANOVA was conducted to determine if there was a significant difference between the subjects' percent correct scores for each trial type. No significant difference between trial types was found (Friedman's χ^2 (3) = 2.1).

General Discussion

The goal of the present set of experiments was to determine whether eye gaze could direct a cotton top tamarin's attention to a novel object without explicit training, (Experiment 1), or to a baited object (Experiment 2), and whether the use of various directional cues (i.e., pointing, gaze, or glance) were differentially used by individuals of the species in the different tasks. Results indicated that cotton top tamarins do not visually co-orient with experimenter-given cues to a distal object. By their absolute frequencies of visual co-orienting, cotton top tamarins responded much like lemurs in the Anderson and Mitchell (1999) study, who also failed to visually co-orient with humans consistently. The rate that they showed this behavior was opposite the pattern found for old world monkeys (specifically macaques) and apes (specifically, chimpanzees, orangutans, and human infants) in similar studies using experimenter-given cues.

All tamarin pairs oriented in correlation with each other, yielding a significant positive relationship between them. This finding indicates that conspecific co-orienting correlates well, whereas cross-species co-orienting (monkey to human) in this species is

not generated well. The data confirm a methodological concern in gauging the co-orienting ability of animals by demanding that they co-orient with a human experimenter.

Still, with a human experimenter as a guide, the rate of visual co-orienting was significantly increased by hand pointing cues as compared to a "look" cue that consisted of head, eyes, and body oriented toward the stimulus, , or to a "head gaze" cue that consisted of head and eyes oriented toward the stimulus. This was true with the original experimenter giving the cues, and in the test with a novel experimenter giving cues in one 42-trial session. Physical proximity of a body part to a stimulus seemed to generate the most shared attention between any human guide and the subjects. Such a cue should not be interpreted as evidence of the species understanding the referential nature of pointing, however, because the cue may be effective simply because it allows a close spatial relationship between the cue and the object. It is also the case that members of this species have never spontaneously demonstrated pointing in the wild or in captivity, which again undermines the referential understanding attached to the increased success of the cue pointing.

It is important to note that the methodology for testing visual co-orienting in Experiment One makes it hard to determine a base rate of looking. For each trial, a full 8 seconds of looking in three different directions (toward stimulus1, toward stimulus2, or neutral look straight ahead) was coded, and each of these looks could occur multiple times per trial. Moreover, the tamarins seemed focussed on observing their cage environment often, and would briefly glance at the experimenter while remaining vigilant toward the cage space. It is unclear at what frequency one would suggest that these subjects were reliably visually co-orienting. By our casual observation, the cotton top

tamarins' instinctive social surveillance behaviors seemed to prevent them from engaging in co-orienting for long periods of time, or at higher frequencies than looking toward the experimenter and toward the cage environment.

A chance level of responding is more verifiable in an object choice task, and in Experiment 2, it was clear that 4 naïve cotton top tamarins made accurate choices at rates higher than chance when a human guide gave a point/tap cue or a "look" cue involving head, eye, and body orientation. As in Experiment 1, a spatial relationship between a cue (finger) and an object produced accurate responding, especially when touching coincided with the visual cue as happened in the point/tap trials. The most intriguing finding in Experiment 2 was the highly successful use of the look cue by subjects, because this cue was paired with non-reinforcement (on no reinforcement trials and on opposite cups trials) much more often than it was paired with obtaining reinforcement (standard look trials). In other words, for predicting the possibility of reinforcement, the look cue was probably the worst cue to rely on, yet subjects followed this cue 74% of the time! The results from the object choice task further confirmed the importance of body proximity and body orientation for shared attention to emerge, but also highlighted the use of head/eye orientation when food may be indicated.

Some interesting individual differences emerged that are important to note. First, one subject showed some learning of the use of experimenter-given cues in the object choice task, thus it may be possible that individuals of the species could be trained to attend toward directional cues, as was the case with another new world monkey species, capuchins (Vick and Anderson, 2000). Secondly, while point/tap and look cues generated significantly higher response accuracy across the subjects as a group, it was clear that

some subjects used particular cues more consistently than did others. For example,

Caitlin, the oldest female and mother of the family tested in the object choice task, did

not respond accurately when point or when point/tap cues were used, and her behavior

during these trials was very informative. If an experimenter positioned his or her hand

above or on a cup, Caitlin would look at the cup, assume a low submissive position on

the cart with her body, and then physically knock over the opposite cup. Caitlin did use

the "glance" cue successfully to find food, whereas most other subjects could not utilize

that cue. In contrast, Dante, the oldest male in the family, did not hesitate to knock over a

cup which was being touched or pointed to by an experimenter, but could not attend to

the glance cue to find food. In fact, avoidance of approaching a pointing stimulus in some

of the subjects generated a great deal of variance in the pointing cue condition.

The "glance" cue, or a cue that relies on eye direction alone, is one that has eluded

training for use in capuchins, the other tested new world monkey species, and was the cue

that gorillas could not consistently use in Peignot & Anderson (1999). It is worth noting

in this study that two of the 4 participating subjects in the object choice task responded

very accurately during glance cue trials, while the other two subjects could not use it as

an informative cue. While the glance cue is not one that reliably generated accurate

choices in the subjects as a whole, there is some indication that it could be utilized by

individuals of the species. Further training is in order to test this cue properly.

One concern in this set of studies was that different species of primates would be

differentially motivated to use experimenter-given cues that involve eye, head, and/or

body orientation. By social application, direction of eye gaze, usually accompanied by

head and body orientation, serves a simpler purpose of a display of a threat when the gaze

is exacted at another. In many species, it may draw attention, but only when the gaze is directed at self, and so gazes by themselves directed at distal objects in directions other than towards the self may not draw much interest. A hand orientation may be a more effective cue to follow, especially when the reason for looking remains elusive. Body approach, body orientation, and body part proximity may indicate potential sources of food, and thus these cues would be more likely to elicit some attention by primate subjects. Social primates who do not actively share food, such as most old world and new world monkeys,(see Tomasello & Call, 1997) may use eye/head orientation and hand proximity to determine whether another animal is eating. For these purposes, cotton top tamarins may attend to eye/head cues and pointing/touching particularly when sources of food are possible. The data from these two studies support such speculation, for with distal objects, body proximity was the more effective attention-getting cue, while for food locations, both head/eye cues or body proximity by way of touching were the prominently used cues. Clearly, the lack of eye-orientation noting in tamarins indicates a limitation on understanding another's perspective from a direction of glance. More generally, tamarins' understanding of another's attention seems limited to a spatial relationship between another animal and an object of interest, and the orientation of an animal's head/body and food. This explanation seems far simpler than the mind reading that is implied by the visual co-orienting of some chimpanzees, orangutans, and human infants.

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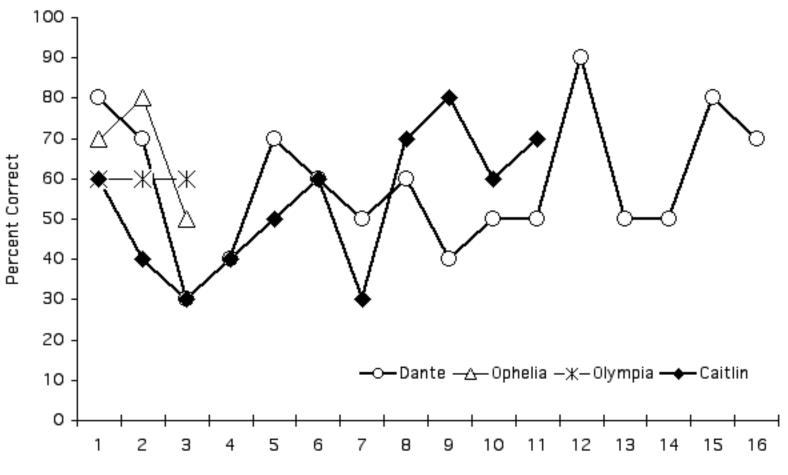
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Figure Captions

Figure 1. Averaged percent of visual co-occurrence (VCO's) following each type

of cue (point, look, or head gaze) with the original experimenter, and with a novel

experimenter.

Figure 2. Percent correct scores for each consecutive block of 10 trials in the two-

choice experiment. (A score of 50% is chance level responding.)

Figure 3. Median percent correct scores for a total of 4 subjects in the two-choice

experiment, displayed for each cue condition (Point/Tap, Point, Look, and Glance). Look

trials included standard baited trials, trials that were not baited (no reinforcement trials),

and trials in which the cup not cued was the one baited (opposite cup trials).