**Do capuchins follow conspecific gaze and can they use gaze information to solve a target-choice task?**

**Introduction**

Primate social live hinges on navigating complex relationships and hierarchies via cooperative and competitive social maneuvering for access to limited resources. The ability to track, predict, and exploit the mental states of others, would therefore be an adaptive socio-cognitive ability to overcome the challenges of group life. Gaze following, or looking in the direction another is looking in, is widespread across species, and can allow individuals to acquire information related to food availability and predator detection and can be further used for both cooperative and deceptive social maneuvering (reviewed in Zeitrag et al. 2022). Considering the utility of gaze-following in navigating social situations, it seems likely that a social and group-living species like capuchin monkeys (Fragaszy et al., 2004; Gazes et al., 2022), would benefit from being able to keep track of and act upon the gaze of others; however current literature on capuchins’ ability to track and exploit another’s visual information is lacking.

Capuchins possess the largest relative brain size of any primate species, second only to humans, despite their divergence from humans 35mya (Orkin et al., 2021), representing an ideal species for investing both the evolutionary origins of perspective-taking in human and nonhuman primates, as well as the socio-ecological pressures driving ToM to convergently evolve. Capuchins live in large multi-male, multi-female social groups, and must keep track of and navigate transient dominance hierarchies (Fragaszy et al., 2004). In doing so, they exhibit a high degree of social tolerance via food sharing (De Waal & Brosnan, 2006) and exhibit impressive cooperative abilities such as cooperating in joint tasks in captivity (Brosnan et al., 2010; Mendres & De Waal, 2000; Takimoto & Fujita, 2011) and during coalitionary defense in the wild (Perry et al., 2004). Capuchins have also been shown to exhibit deceptive behaviors during experimental captive and field based tasks (Di Bitetti, 2005; Fujita et al., 2002; Kean et al., 2017; Wheeler, 2009). However, current research into the degree to which capuchins utilize this social information has yielded conflicting results.

All primate species currently tested have successfully demonstrated gaze following abilities to different degrees (Reviewed in: Zeitrag et al. 2022). Capuchins can geometrically follow a *human* experimenter’s gaze, moving their position to follow gaze around the barrier, suggesting that they are not simply following a line of sight (Amici, Aureli, et al., 2009). However, unlike macaques and chimpanzees (Reviewed in: Rosati and Hare, 2009), capuchins will not look back to the experimenter if they cannot find the target of the experimenter’s attention (Amici, Aureli, et al., 2009). Capuchins consider a recipient’s orientation when requesting food from an experimenter (Hattori et al., 2007, 2010), yet did not alter their frequency or duration of pointing between these different attentional states, when requesting food, suggesting that capuchins are sensitive to a humans attentional state yet do not direct them. However, these results were challenged by (Defolie et al., 2015), in which capuchins pointed more frequently and for a longer duration to a baited cup when a human experimenter was present and facing them than when they were outside of the room or turned away. This suggests that capuchins can learn to use a referential pointing cue over trials yet may not do so spontaneously. These results suggest that capuchins are tracking the attentional states of others yet are limited in their ability to exploit them under cooperative contexts. These results support consistent evidence that primates do not *spontaneously* produce or utilize socio-communicative cues to find hidden food during interactions with a *human* experimenter (Anderson et al. 1995; Bräuer et al., 2006; Povinelli et al., 1990, 1996, 1997; Tomasello et al., 1997, Hare & Tomasello, 2004); argued to be due to sharing and exploiting socio-communicative cues under cooperative contexts lacking ecological validity within primates’ competitive social lives. However, the degree to which capuchins utilize *conspecifi*c cues such as gaze remains unstudied.

This limitation in explicitly utilizing the attentional states of others has been further identified during competitive paradigms (Hare et al. 2003). Unlike chimpanzees (Hare et al. 2000), rhesus macaques (Flombaum & Santos, 2005), and ring-tailed lemurs (Bray et al. 2014), capuchins tested in a competitive food paradigm did not strategically adjust their behavior based on what a dominant conspecific could and could not see and instead reacted to the presence of a dominant (Hare et al, 2003). In a competitive food paradigm, subordinate capuchins preferentially approached food that was hidden verses visible from a dominant. However, when they were released first and given a head start, subordinates approached the visible and hidden food options randomly, only adjusting their approach towards the hidden food when the dominant entered (Hare et al. 2003). This suggests that capuchins are generally avoiding dominants rather than exploiting their visual perspectives, despite evidence of sensitivity to others’ attentional states. Thus, current literature suggests that capuchins are able to track attentional states yet may be unable to exploit them under both cooperative and competitive paradigms. Further, the majority of studies investigating capuchins sensitivity to social attention has been restricted to human attention rather than conspecific, causing evidence of tracking and exploiting of gaze to be mixed and lacking. This all suggests that capuchins have a rudimentary awareness of what others see, but to what extent they utilize and exploit this visual information to inform their decisions remains an open question.

Eye tracking is quickly becoming an innovative method to understand what information is socially relevant across species (Reviewd in: Lewis & Krupenye, 2022). Using non-invasive techniques, primates are capable of gaze-following from static and video stimuli, yet performance is affected by the stimuli used, such as model identify and motion. When viewing still images of humans and conspecifics looking towards a target rather than distractor icon, Hattori and colleagues (2010) showed that chimpanzees followed gaze of a conspecific but not a human. Similarly, when presented with a video of a human, conspecific, and allospecific turning their head repeatedly towards a target, bonobos and orangutans followed the gaze of both conspecific and allospecific agents (human and other apes), while chimpanzees only followed the gaze of conspecifics. Additionally, results from macaques, titi monkeys and apes suggest that subjects attend more to social stimuli when presented with videos rather than still pictures (Reviewed in Lewis and Krupenye, 2022).

Eye tracking has been successfully used with capuchin monkeys to investigate attentional preferences of conspecific faces (Lonsdorf et al. 2019; Sosnowski et al. 2022), and the effect of social models on memory (Howard et al. 2018), it has not yet been used to investigate gaze following, representing an opportunity to test if and how capuchin monkeys utilize *conspecific* gaze. Since results from Sosnowki and colleagues (2022) suggest capuchins’ attentional preference for eyes rather than mouth regions on conspecific faces, they may be sensitive to the gaze of conspecifics as well.

Eye tracking has further challenged what is known about the degree of perspective taking in nonhuman primates, as evidence from studies using implicit measurements such as gaze following (Krupenye et al. 2016) suggest different perspective taking abilities when compared with explicit measurements such as making a choice (Hare et al. 2001), arguing that these methods can yield conflicting results.

Therefore, in the present study, we will present capuchins with videos of a conspecific looking in two different directions (upper left and upper right; modeled after Kano & Call, 2014), while an eye tracker measures first looks and looking time to target and distractor icons. This will be the first study to investigate conspecific gaze following in capuchins. Importantly, capuchins must then use this gaze information to correctly select one the target or distractor icon in a dichotomous target-choice task. Although previous evidence suggests an inability to utilize socio-communicative cues in cooperative contexts (Hare & Tomasello, 2004), due to this population’s familiarity with cooperative and computerized target-choice tasks, monkeys in this study may be more motivated to use gaze as a cue to when making an explicit choice. By implicitly measuring whether capuchins can follow a conspecifics gaze using an eye tracker and whether their explicit choices align with their implicit response during the target-choice task, we will be able to identify if capuchins not only perceive gaze as a salient social cue but also utilize it when making decisions. We will explore this question from two angles in two different but related experiments.

*Experiment 1*

Experiment 1 will test if capuchins spontaneously, without any training or reinforcement, follow a conspecific’s gaze to a target. If the capuchins do spontaneously track this social information and follow a conspecific’s gaze with their eyes (an implicit process), we predict that their first look, as measured via eye tracking saccades, and total fixation time, will be directed towards the target the conspecific is looking at. Due to eye tracking data showing conspecific gaze following in apes (Hattori et al. 2010; Kano et al. 2014) macaques (Shepherd et al. 2009) and marmosets (Spadecenta et al. 2019), as well as capuchins following a human experimenter’s gaze (Amici et al., 2009), we expect capuchins to follow conspecific gaze.

Additionally, if the capuchins spontaneously use gaze to inform decisions in a dichotomous target-choice task (an explicit process), then we predict they will correctly select the target that the conspecific is looking at above chance levels, even when they are not reinforced for selecting either target. If conspecific gaze is salient social information for capuchins, they are expected to follow and utilize the gaze direction of a conspecific in the social trials, and not the movement of the stimuli in the asocial trials. However, regardless of whether capuchins spontaneously follow gaze of a conspecific, they may not explicitly use gaze during the target-choice task and may instead need to learn to use it in their decisions, in which case we will conduct a second experiment.

*Experiment 2*

Experiment 2 will test if capuchins are able to learn to use conspecific gaze to guide their response in the target-choice task. Unlike the first experiment, capuchins will be reinforced based on whether they select the correct or incorrect icon. Therefore, they can learn that the social cues from the conspecific on the screen will guide them to the correct decision. Since previous work has shown that capuchins can learn a reaching behavior to guide a human’s attention over trials (Anderson et al. 2001; Defolie et al., 2015), we expect capuchins to learn to use the gaze cue to receive a reward by choosing the correct target icon. If gaze direction can be learned to be used as a salient cue to inform decisions, capuchins are expected to show a learning curve such that they correctly chose the target icon the social stimuli is directed to. Eye tracking will not be used during Experiment 2.

Monkeys that are unable to participate in eye tracking, such as those from Griffin’s group (eye tracker does not fit in their testing area), will participate in only experiment 2, with Lily as their social stimuli.

**Methods**

***Subjects***

We will test the tufted capuchin monkeys housed at Georgia State University’s Language Research Center (LRC) in Atlanta, GA. In total, there are 28 capuchin monkeys at the facility (8 M, 20 F), however, because the eye tracker is too large to fit in the testing space for one of our groups (Griffin, n = 5), as well as each group’s alpha female not participating due to them being the social stimuli, we will only be able to test a maximum of 7-9 monkeys in experiment 1 (simultaneous implicit and explicit measures). Experiment 2 should allow for approximately 12 monkeys. All testing at the LRC is completely voluntary, meaning all subjects can choose not to participate by either not separating for testing or refusing to complete trials once in their testing box. In addition, in order to test, each subject must get a calibration on the eye tracker, which in our experience is not possible for some monkeys.

All subjects at the LRC live in mixed-sex social groups with their own dedicated indoor and outdoor enclosures. These capuchins are trained to voluntarily separate from their social group into individual testing boxes (attached to their indoor enclosures) where they routinely complete non-invasive computerized testing using a hand-controlled joystick (Evans et al., 2008). As with all studies at the LRC, this study will be completely voluntary, and the capuchins will never be deprived of food, water, social contact, outdoor time, or enrichment to motivate testing.

***General Procedure***

***Experiment 1***

***IMPLICIT AND EXPLICIT TOGETHER:***

Capuchins will be tested on a computerized dichotomous choice task coded using python 3 programming language (van Rossum & Drake, 2012). The task will consist of three types of trials: **(1) Social** trials, **(2) Asocial eyes** control trials, **(3) Asocial object** control trials, and **(4) Motivation** trials. Social and asocial control trials are considered **Critical trials** because they will be analyzed, while motivation trials are to keep monkeys motivated in the task and will not be analyzed. In **Critical trials (social and asocial trials)**, two **identical** icons will be presented in the top corners of the screen. Critical trials will not be rewarded, so identical icons are used to prevent monkeys from attempting to learn which icon is correct. **Social** trials involve a video of a conspecific (each group’s alpha female) looking in the direction of one of the two stimuli presented at the top of the screen. Asocial trials involve a 3D object rotating towards one of the two stimuli. During the first two seconds of critical trials, an eye tracker will measure the first icon the subject looks to at the onset of the video stimulus as well as the duration of time spent looking at each icon. After 2 seconds, monkeys will be cued to make a dichotomous target choice between the two icons.

The purpose of the asocial conditions are to control for whether capuchins’ visual attention and/or explicit choices are guided by perceptual or motion cues that are directed to the target icon rather than if they are using conspecific gaze and head direction (Heyes, 2015). To further control for the use of eyes in general in guiding social attention and explicit choices, a second asocial condition called **Asocial eyes**, will be presented, in which the video of the 3D object has black dots that simulate the shape and motion of eyes and gaze direction.

Because we are interested in whether capuchins follow gaze spontaneously, without reinforcement and learning, critical trials will not be rewarded. Instead, motivation trials will be presented after each critical trial. This ensures monkeys remain motivated and reinforced to engage in the computer task and keeps their attention on the screen for the eye tracker, without providing information on how to solve the critical trials. Black occluders will be placed on the left and right side of the subject’s individual testing box to reduce distractions.

***Social Stimuli***

For each group, the social stimuli will be the alpha female to control for differences in attentional preferences between sexes (Lonsdorf et al. 2019) and relationships (Talbot, 2016), although future variations of this study can address these questions further. Alpha females as stimuli ensure that the stimuli are salient to the monkeys. Although this may also cause individuals to potentially avoid an alpha’s gaze, this can be compared across future studies with different individuals as the social stimuli.

Each monkey group will therefore see the social stimulus of their alpha female in their indoor enclosure. Two sets of videos will be included to ensure variation in video presentation. One video of the alpha looking left will be flipped to also be included as their video looking right. A second video of the alpha looking right will be flipped to be included as their video looking left. This will result in 4 social videos per alpha monkey. Upon presentation, the video will play for 2 seconds, which will involve the alpha looking forward, towards an icon (left or right), forward again, towards the same icon, and then forward again. After this time, the curser will appear, cueing the monkey to make a choice between targets. Videos will continue to play during this time to keep attention and ensure that monkeys are responding to the videos and not a still image. Videos were cropped so that they included the least number of extraneous objects in the background. All other stimuli videos were cropped to a similar size.

*Stimuli collection*

Videos of alpha female capuchins for each group were recorded in the joint or individual boxes of their indoor enclosures using an Iphone 11. Experimenter 1 holds the box door open, sallowing the capuchin to enter the box yet staying at an appropriate distance from the camera. Experimenter 2 holds their Iphone to the enclosure while directing the capuchins’ gaze to the center, upper left, and upper right direction using cheerios. Videos will be of individual monkeys that are stationary, with a neutral expression, closed mouth, and no chewing or forehead movements. Despite efforts to keep the background consistent, videos will differ based on enrichment and enclosure layout.

Videos were then edited in IMovie. A video of a subject looking forward and then into one direction was then reversed so they looked back towards their starting position. This was then looped so the monkey starts in a forward gaze direction, then looks towards a target and back to a forward direction for a total of two times, resulting in a two second video. Videos of alpha females looking in one direction were then mirrored so that they were looking in the opposite direction. Videos were adjusted for light and contrast to ensure comparability across stimuli. Kano and Call (2014) conducted a similar experiment using apes and had videos repeated 5-3 times using 10 second videos. Our time frame differs because the previous study had subjects drinking juice during the video.

***Asocial Control Stimuli***

*Asocial object condition*

Asocial stimuli will consist of one 3D object rotating in the direction of an icon (left and right), simulating the perceptual and motion cues of a monkey’s head turn. Only on version of each “asocial object” and “asocial eye” stimuli will be used. Similar to the social stimuli, the 3D object will rotate from the forward-facing position to the direction of an icon, then forward, then towards the icon, then forward again, lasting two seconds. Timing and pace of stimuli are matched between social and asocial trials, such that each video of looking towards an icon twice is a two second video. Backgrounds of social and asocial trials will be matched. A still image taken from the social video stimuli of the indoor enclosure and joint box will be the background of the asocial trials, ensuring that the only perceptual difference between videos is the 3D object vs monkey. Although eye tracking measurements could detect capuchins following the movement of the icon, whether or not they use it as a social cue would be dependent on if they follow that direction past the control stimuli to the target icon.

The 3D object was created using the computer program, Blender. Still images of the group’s alpha female’s fur were taken from social videos, and overlayed onto the 3D image. This allows for texture and color matching between social and asocial trials. The object was then pasted in front of a still image from the social video’s background. By screen-recording Powerpoint, objects were rotated in each direction. Using iMovie, videos were then flipped to rotate in the opposite direction. Similar to social trials, asocial trials of the object looking towards the target twice resulting in a two second video. Asocial trials follow the same pattern as social trials, such that after 2 seconds, the curser will play, at which time monkeys can make a choice between the two targets, yet the video will still play continuously until he next trial.

*Asocial Eyes condition*

To control for whether monkeys are following perceptual movement verses eye-like movement, an additional asocial trial condition will have the same 3D object, but with small black eyes on the objects, that look towards an icon when it rotates towards it.

***Motivation Trials***

In **Motivational** trials, two **different** icons will be presented on the screen and only one will be the correct selection. Icons will be distinct from each other and different from the icon used in critical trials. With the same background as the social and asocial trials (indoor enclosure’s joint box), a video of a different 3D object in motion will play. This ensures that monkeys are not associating a blank screen without a video as a reward trial, and prioritising their attention and participation based on that perceptual cue. The stimuli will have two versions involving a blue 3D textured object rolling either forward and backwards. 3D objects were made in blender, motion was captured in PowerPoint, and videos were time-matched with the social and asocial stimuli in iMovie.

***Computerized Task Parameters***

Each trial, regardless of its type, will begin with a start button at the top-center of the screen, and a red cursor just beneath the start button. To begin the trial, the subject must use their joystick to touch the start button with their cursor, at which point the start button and cursor will disappear. The stimulus video will be presented below two icons (identical icons for critical trials and different icons for motivation trials). Video stimuli will be either of the alpha female (social trial), 3D object with eyes (asocial eyes trial), 3D object without eyes (asocial object trial), or a colorful 3D object (motivation trial). The video will play for 2 seconds, at which time the curser will appear in between the icons, signalling to the monkeys to make a choice. The video stimuli will continue to play while monkeys are making their choices, however eye tracking data will only be measured in critical trials during the first 2 seconds after video presentation. After target selection, there will be an ITI of 2 seconds, unless monkeys who received a motivation trial chose incorrectly, in which case they will receive a 5 second ITI. Only the motivation trials will be rewarded. When the correct icon is chosen in motivation trials, a ding sound will play and the subject will receive one 45-mg banana flavored pellet (BioServ). If an incorrect icon is selected, a buzz sound will play, and no pellets will be distributed. In critical trials, after an icon is selected, a motivation trial will immediately begin.

Each block will begin with motivation trials and continue until the subject has chosen the correct response 5 trials in a row. This is to have them learn which icon is correct and to increase motivation and attention. After this time, subjects will receive either a social, asocial eyes, or asocial object trial, pseudorandomized, with a motivation trial in between each critical trial. This will be one block. Each day, monkeys will complete a maximum of 10 blocks.

During motivation trials, if monkeys choose correctly, they will receive a ding and a pellet, with an ITI of 2 seconds. If they choose incorrectly, they receive a buzz, no pellet, and an ITI of 5 seconds. Critical trials are not rewarded; therefore, they will be followed by a motivation trial with an ITI of 2 seconds. Each video will play in motion for 2 seconds before the curser appears, prompting monkeys to make a choice, therefore each trial should take a minimum of approximately 3 seconds (2 seconds for video, 1 second for response). Taken together, each block should range between 38 seconds to 53 seconds. Monkeys will complete 10 blocks in one resulting in a total time of approximately 10 minutes. 10 blocks will be completed in one testing day.

*Example:* **Motivation trials until monkey reaches 5 correct trials -**  **Social-** 2s- **M** 2-5s - **Asocial Eyes** – 2s – **M** – 2-5s – **Asocial object** – 2s

Click here to view: [Social Stimuli](https://drive.google.com/drive/folders/1m0H_TDi5QSlHwvuW5WZZc3wuEJGtPGmx?dmr=1&ec=wgc-drive-hero-goto)

Click here to view: [Asocial Object Stimuli](https://drive.google.com/drive/folders/1is6qII9Wztt23i9ZSI8siQ6zgb62WbXe?dmr=1&ec=wgc-drive-hero-goto)

Click here to view: [Asocial Eyes Stimuli](https://drive.google.com/drive/folders/1sv6IVdeIF4cxEevBLWU3k9QispIjheIL?dmr=1&ec=wgc-drive-hero-goto)

Click here to view: [Motivational Stimuli](https://drive.google.com/drive/folders/1zEOBozdhYq7l8bhSj11CeLQraryt1bzB?dmr=1&ec=wgc-drive-hero-goto)

***Eye tracker Apparatus***

To track the subject’s gaze, we will use a Tobii TX300 Eye tracker set up, which includes the eye tracker, a 1920 x 1080 pixel monitor, desk computer running Tobbii studio, pellet dispenser, joystick, and experimenter monitor. The setup operates on Tobii Pro Lab v. 1.30 and Tobii SDK. To calibrate the eye tracker, we will use a two-point calibration, which was previously used with this population (Sosnowski et al., 2022) and is often used for human infant populations. Live calibrations will be conducted in which a stimulus will be presented to the monkey, while an experimenter hits the spacebar to confirm each calibration. Measurements will be obtained for each monkey, and calibration will be checked before the start of each trial. Areas of Interest (AOIs) will be identified as left of screen, and right of screen, as well as in the center where the stimuli are presented.

***Measures***

Eye tracker data will be continuously collected during critical trials, however the most important time point will be during the first 2 seconds upon video presentation. We will measure the first icon attended to within the 2 second time period, as well as duration of time spent looking at the target and distractor icon. We will also measure Differential Learning Scores [DLS; total number of looks to the target minus total number of looks to distractor icons divided by the sum of the values; Horschler et al. 2020)], to determine if target icons are prioritized over the distractor icon. We will also measure the amount of time subjects looked at the video stimuli. These measures will be compared between social and asocial control conditions. Further comparison will be between asocial eyes and asocial object, to identify if there are particularly salient cues monkeys are using (motion vs dots).

Explicit choices will be measured as the proportion of times monkeys chose the target icon compared to the distractor icon in all critical trials (social, asocial eyes, asocial object).

***Experiment 2***

To determine if monkeys who do not spontaneously use this information can still learn to use the gaze of others to guide their decisions, any subjects that fail to select the correct icon in the social trials above chance will be tested in Experiment 2. This experiment will be nearly identical to Experiment 1 with one exception. The Social and Asocial trials will now be differentially reinforced based on whether the correct icon is selected, despite icons being identical. Because both icons are identical, the only way to determine which icon is the correct choice will be to use the guiding stimulus (conspecific gaze or asocial stimuli) in the middle of the screen. Motivational trials will still be included to keep trial numbers similar across experiments.

In Experiment 2, the Social and Asocial trials will also be rewarded. After each trial, there will be a 5-second intertrial interval (ITI). In differentially rewarded trials, selecting the incorrect icon will result in an additional 10-second time out before the next trial. The location of the correct icon will be counterbalanced so that it appears on both sides an even number of times, and pseudorandomized such that it does not appear in the same location in more than three consecutive trials. Subjects will complete a total of 600 trials per day: 100 social, 100 asocial eyes, 100 asocial objects, 300 motivations. We will test the monkeys for 5 days, or up to an additional 2 days if they did not complete the task within 5 days, resulting in a total of 3000 trials. The program will then quit once they reach the 600 trial count for that day.

Trials will be pseudorandomized such that the same trial type does not occur in more than three consecutive trials. Learning curves will be measured for each critical condition once the 600 trials are complete. Learning will be measured by number of trials needed to reach 80% criterion of correct choices and will be compared between social and asocial control conditions. We will compare number of correct trials as well as time to criteria between social, asocial eyes, and asocial object conditions. This will determine if monkeys are able to learn the gaze cue faster from a social rather than asocial model.

Monkeys who are unable to participate in eye tracking will skip right to experiment 2, and be tested in their ability to explicitly chose the icon their stimuli is looking towards.

**(Experiment 3 - Splitting up the task)**

If simultaneously measuring implicit and explicit measures during a python task does not work, we will separate the study into 1) eye tracking videos and 2) dichotomous choice.

***General Procedure – Eye tracking***

Capuchins will be presented with the same 3 conditions of video stimuli: **(1) Social** trials, **(2) Asocial eyes** control trials, **(3) Asocial object** control trials. Videos will be presented for a total of 10 seconds, during which time an eye tracker will measure the first icon the subject looks to at the onset of the video stimulus as well as the duration of time spent looking at each icon.

Because we are interested in whether capuchins follow gaze spontaneously, without reinforcement and learning, trials will not be rewarded. To maintain capuchins attention, we will 1) smear peanut butter on plexiglass face plates to direct capuchins attention to the eye tracker, or 2) provide capuchins with an IV drip that slowly provides juice. The spout will be positioned at mouth level, such that capuchins eyes are in a relatively still and stable position. This will keep capuchins attention directed to the eye tracker while providing them with incentive to view the screen. Black occluders will be placed on the left and right side of the subject’s individual testing box to reduce distractions.

Monkeys will first receive an attention-getter for 2 seconds, then will be presented with 3 consecutive 2-second videos that will be pseudorandomized between social, asocial eyes, and asocial object, resulting in a total block of 8 seconds. Capuchins will then have a 30 second ITI and then be presented with the second block. During the ITI, capuchins’ juice drip will be stopped. After 30 seconds, the experimenter will then turn on the juice drip and present the next block. Monkeys will participate in a total of 10 blocks.

*Example:* Attention getter (2seconds) – Social (2 seconds) – Asocial eyes (2 seconds) – Asocial object (2seconds) = 1 block x 10

***General procedure – Computer task***

Without the eye tracker, monkeys will then be presented with a computerized target-choice version of the gaze task. This will follow the same procedure as in Experiment 1 and 2. The computer task will always come after the eye tracking task to ensure that monkeys are not learning the correct cues before the eye tracker can test their spontaneous response.

**References**

Amici, F., Aureli, F., Visalberghi, E., & Call, J. (2009). Spider monkeys (Ateles geoffroyi) and capuchin monkeys (Cebus apella) follow gaze around barriers: evidence for perspective taking?. *Journal of Comparative Psychology*, *123*(4), 368.

Bettle, R., & Rosati, A. G. (2021). The primate origins of human social cognition. *Language Learning and Development*, *17*(2), 96-127.

Bray, J., Krupenye, C., & Hare, B. (2014). Ring-tailed lemurs (Lemur catta) exploit information about what others can see but not what they can hear. *Animal cognition*, *17*, 735-744.

Defolie, C., Malassis, R., Serre, M., & Meunier, H. (2015). Tufted capuchins (Cebus apella) adapt their communicative behaviour to human’s attentional states. *Animal Cognition*, *18*, 747-755.

Fujita, K., Kuroshima, H., & Masuda, T. (2002). Do tufted capuchin monkeys (Cebus apella) spontaneously deceive opponents? A preliminary analysis of an experimental food-competition contest between monkeys. *Animal Cognition*, *5*, 19-25.

Flombaum, J. I., & Santos, L. R. (2005). Rhesus monkeys attribute perceptions to others. *Current Biology*, *15*(5), 447-452.

Gazes, R. P., Schrock, A. E., Leard, C. N., & Lutz, M. C. (2022). Dominance and social interaction patterns in brown capuchin monkey (Cebus [Sapajus] apella) social networks. *American Journal of Primatology*, *84*(3), e23365.

Hare, B., Call, J., Agnetta, B., & Tomasello, M. (2000). Chimpanzees know what conspecifics do and do not see. *Animal Behaviour*, *59*(4), 771-785.

Hare, B., Call, J., & Tomasello, M. (2001). Do chimpanzees know what conspecifics know? Animal Behaviour, 61(1), 139–151. <https://doi.org/10.1006/anbe.2000.1518>

Hare, B., Addessi, E., Call, J., Tomasello, M., & Visalberghi, E. (2003). Do capuchin monkeys, Cebus apella, know what conspecifics do and do not see?. *Animal Behaviour*, *65*(1), 131-142.

Hattori, Y., Kuroshima, H., & Fujita, K. (2007). I know you are not looking at me: capuchin monkeys’(Cebus apella) sensitivity to human attentional states. *Animal Cognition*, *10*, 141-148.

Hattori, Y., Kuroshima, H., & Fujita, K. (2010). Tufted capuchin monkeys (Cebus apella) show understanding of human attentional states when requesting food held by a human. *Animal Cognition*, *13*, 87-92.

Hattori, Y., Kano, F., & Tomonaga, M. (2010). Differential sensitivity to conspecific and allospecific cues in chimpanzees and humans: a comparative eye-tracking study. *Biology Letters*, *6*(5), 610-613.

Horschler, D. J., MacLean, E. L., & Santos, L. R. (2020). Advancing gaze-based research on primate theory of mind. *Trends in Cognitive Sciences*, *24*(10), 778-779.

Howard, L. H., Festa, C., & Lonsdorf, E. V. (2018). Through their eyes: The influence of social models on attention and memory in capuchin monkeys (Sapajus apella). *Journal of Comparative Psychology*, *132*(2), 210.

Kano, F., & Call, J. (2014). Cross-species variation in gaze following and conspecific preference among great apes, human infants and adults. *Animal Behaviour*, *91*, 137-150.

Kano, F., Moore, R., Krupenye, C., Hirata, S., Tomonaga, M., & Call, J. (2018). Human ostensive signals do not enhance gaze following in chimpanzees, but do enhance object-oriented attention. *Animal Cognition*, *21*, 715-728.

Kean, D., Tiddi, B., Fahy, M., Heistermann, M., Schino, G., & Wheeler, B. C. (2017). Feeling anxious? The mechanisms of vocal deception in tufted capuchin monkeys. *Animal Behaviour*, *130*, 37-46.

Krupenye, C., Kano, F., Hirata, S., Call, J., & Tomasello, M. (2016). Great apes anticipate that other individuals will act according to false beliefs. *Science*, *354*(6308), 110-114.

Lewis, L. S., & Krupenye, C. (2022). Eye‐tracking as a window into primate social cognition. *American journal of primatology*, *84*(10), e23393.

Lonsdorf, E. V., Engelbert, L. M., & Howard, L. H. (2019). A competitive drive? Same‐sex attentional preferences in capuchins. *American Journal of Primatology*, *81*(6), e229

Mitchell, R. W., & Anderson, J. R. (1997). Pointing, withholding information, and deception in capuchin monkeys (Cebus apella). *Journal of Comparative Psychology*, *111*(4), 351.

Orkin, J. D., Montague, M. J., Tejada-Martinez, D., De Manuel, M., Del Campo, J., Cheves Hernandez, S., ... & Melin, A. D. (2021). The genomics of ecological flexibility, large brains, and long lives in capuchin monkeys revealed with fecalFACS. *Proceedings of the National Academy of Sciences*, *118*(7), e2010632118.

Shepherd, S. V., Klein, J. T., Deaner, R. O., & Platt, M. L. (2009). Mirroring of attention by neurons in macaque parietal cortex. *Proceedings of the National Academy of Sciences*, *106*(23), 9489-9494.

Sosnowski, M. J., Kano, F., & Brosnan, S. F. (2022). Oxytocin and social gaze during a dominance categorization task in tufted capuchin monkeys. *Frontiers in Psychology*, *13*, 977771.

Spadacenta, S., Dicke, P. W., & Thier, P. (2019). Reflexive gaze following in common marmoset monkeys. *Scientific Reports*, *9*(1), 15292.

Talbot, C. F. (2016). Discrimination of Faces, Sex, and Relationships by Capuchin Monkeys.

Zeiträg, C., Jensen, T. R., & Osvath, M. (2022). Gaze following: A socio-cognitive skill rooted in deep time. *Frontiers in Psychology*, *13*, 950935.

A collage of a couple of animals

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