Peek a Boo! Information seeking about food and functionality in capuchin monkeys.

**Abstract**

**Introduction**

Whether for food, mates, or shelter (to name just a few possibilities), many animals engage in information seeking. However, when this information seeking becomes more than just targeted it can be regarded as one form of metacognition. For example, if an individual is both selective (e.g. only searching for information when it is missing) and strategic (e.g. when their search pattern varies with differing knowledge gaps) in their information seeking it eludes to the possibility that they are aware that they lack a specific piece of information. Therefore it can be taken as a sign that they have the metacognitive capacity to “know *what* they don’t know” rather than simply following a predetermined search routine in response to uncertainty.

Studies into animal’s information seeking abilities typically involve hiding a desired object and measuring how and to what degree the animal will search for the object. In a 2001 study by Call and Carpenter, they demonstrated that great apes were aware when they did not know the location of food. The apes had to choose between two tubes, one of which contained a food reward. When the baiting event was hidden, the apes were much more likely to bend down and check the contents of the tubes before choosing. This selectivity in when the apes chose to search, points towards them having the metacognitive awareness of what information they are missing in order to make a correct choice – in this case the food’s location. Additionally, in a following study by Call in 2010, if the tubes were shaken by the experimenter before choosing, then the apes checking reduced, further supporting the idea that that they were checking in response to not knowing the foods location. Using the same paradigm, it has also been shown that when baiting is hidden, macaques will check the contents of tubes before choosing, but when baiting is visible they will choose instantly (Zivin & Murray, 2004). However, when similar food-search paradigms have been presented to capuchin monkeys the results have been mixed. Basile et al. (2009) found that when they presented monkeys with 4 opaque tubes, one of which contained food, 4/5 of the monkeys always searched for food irrespective of the baiting condition. Only 1 capuchin monkey showed a significant tendency to search more often in hidden baiting trials. However, the monkeys in this study underwent a large amount of search training before completing the task and so it is possible they had been inadvertently trained to always search when this apparatus was present. In contrast, with minimal training, Vining and Marsh (2015), had monkeys choose between 2 cups, one of which contained food. The cups were sat on a transparent shelf and so to locate the food during hidden baiting trials the monkeys had to bend down and look up through the shelf. Two of the monkeys passed the test and looked significantly more often when baiting was hidden, with the third monkey showing the same trend but not quite reaching significance.

In all of the studies mentioned above, the object being sought is a food reward. Although this increases the likelihood of the animal being motivated enough to search, it does raise concerns that the strategic food search found is not an example of metacognitive abilities, but rather a reflection of the species foraging strategy. When an animal is hungry it will search for food until it finds it and can satiate its hunger. Therefore it is possible that in food search tasks, the primates are simply following a simple rule of “find the food” meaning that in visible trials no search is required but in hidden trials they search for food without the metacognitive awareness that they don’t know where the food is (Kornell et al., 2007). This concern was addressed recently in a 2017 paper by Bohn et al., where chimpanzees and orangutans were required to search for tools rather than for food. The ape’s attention was first drawn to an out of reach food item before then being drawn to a choice window. At the choice window the apes could select which tool they wanted to attempt to retrieve the food, however, in some trials the apes were able to see the choices before they were occluded, whereas in other trials they were not - requiring the individuals to peek over a barrier to locate the required tool. The authors found that peeking was more common in trials where the apes didn’t have visual access to the tools beforehand, suggesting that their selective search strategy is not exclusive to food search and therefore may in fact demonstrate a form of metacognition. Methodology such as this is yet to be used with monkeys.

A second concern with current information seeking studies is that for all of the tasks mentioned previously, there is only one possible way to search for information. This adds to the possibility that when the primates don’t know where something is they follow a known exploration routine rather than employing a strategic metacognitive information search (Kornell et al., 2007).

In this study we look for evidence that capuchin monkeys try to fill gaps in their knowledge by selectively seeking information about food and functionality. We make two significant modifications to the previously used procedures in the hope that it will provide stronger evidence that any information seeking observed is not simply use of a natural foraging strategy. Firstly we will modify the testing setup to give participants multiple ways to seek information. This will enable us to assess whether the monkeys are monitoring their knowledge state and then being strategic in their search. Secondly, if selective information seeking is supported by domain general abilities then primates should be able to apply their search selectivity to more than just food. Seeking of functional information is yet to be seen in monkeys, however as they are not as prolific at tool use as chimpanzees, our task will differ from Bohn et al. 2017 in the way the non-food information is presented. In previous work (unpublished) capuchin monkeys were shown to understand the causal relation between cups and lids, successfully choosing an open cup over a cup with a lid in order to obtain food. We use their success in that task and incorporate it into this study. As well as searching for knowledge about the location of food, monkeys will be required to search for information about the functionality of the cups containing the food i.e. whether the cup is sealed or open.

We predict that if monkeys are selective about filling gaps in their knowledge, then they should only seek information when it is missing. Further, if monkeys are strategic about filling gaps in their knowledge then their seeking pattern should be different in trials which provide differing knowledge gaps. Finally, if monkeys’ information seeking is underpinned by a flexible, domain general metacognitive ability, then they should exhibit similar seeking patterns for both food and functional information.

**Experiment 1 – Food search**

Evidence for selective information seeking in capuchin monkeys is mixed. Only after training did the majority of capuchins show selectivity in Basile et al.’s task (2009), and although all three of the capuchins showed the expected pattern of looking the basic task in Vining and Marsh’s task (2015), their performances on the following versions were very variable. In both these studies the monkeys only had one way to search for information and training was required in order for them to perform the required seeking action. In this study we use a modification of Vining and Marsh (2009) setup that provides the monkeys with multiple ways to search based on behaviour previously seen occurring naturally in the testing room.

**Method**

*Subjects and Housing*

The capuchin monkeys that participated in the study were housed at the University of St Andrew’s “Living Links to Human Evolution Research” Centre located within the Royal Zoological Society of Scotland’s Edinburgh Zoo. At the Centre the monkeys live in two mixed species communities, with each group made up of common squirrel monkeys (Saimiri sciureus) and brown tufted capuchin monkeys (Sapajus sp.) Both group’s enclosures consist of an indoor capuchin area (7m by 4.5m by 6m high) to which both species have access, an indoor squirrel monkey enclosure (5.5m by 4.5m by 6m high) to which only the squirrel monkeys have access, and a large shared outdoor area (approximately 900m2) consisting of natural vegetation and climbing structures. Situated between the indoor areas is a research room, where, at specified research times the monkeys have access to their testing cubicles. Research sessions took place up to 5 days a weeks, twice a day at 11.15am – 12.45pm and 2.15pm -4pm Monday-Fridays. Subjects came from both of the groups at the centre; the East group and the West group. The two groups live in adjacent enclosures which are a mirror image of each other, under identical housing conditions and similar size social groups. The monkeys are fed a variety of fruits, vegetables, cereals and insects several times per day. The monkeys are never food deprived and water is available ad libitum. All participant in experiments was voluntary and all food rewards provided (peanuts, raisins, and dates) were supplemental to the monkeys’ daily diet.

*Setup*

All monkeys were tested in the familiar testing cubicles, which they enter voluntarily and are able to leave at any time. The general setup was based on previous information seeking studies (Vining & Marsh, 2015; Call & Carpenter, 2001; Call, 2010, Bohn et al., 2017). Participants entered into the testing cubicles and were given access to two adjacent cubicles. In the door of one of the cubicles we installed a Plexiglass panel with 3 evenly spaced holes … from the bottom. Behind these holes was a transparent plastic stand (…..) onto which the cups were placed during trials. The stand was positioned ... cm away from the window just out of arms reach, as this was the distance at which, during opaque trials , in order to peek into the top section of the cup, the monkeys had to stand up.

The cups comprised of two compartments (figure 1.). Food could be hidden underneath the cup inside the bottom compartment, and/or dropped inside the top compartment. The two compartments were attached slightly unaligned so that the monkeys could not mistake that food dropped in the top would fall through to the bottom. In transparent trials a set of transparent cups was used, and in opaque trials an identical, but opaque set was used. In every trial one of the cups only contained food in the top compartment, one only contained food in the bottom compartment, and one contained food in both compartments.

*Procedure*

At the beginning of each trial an occluder was placed across the window of the testing cubicle, blocking the monkey’s view of the stand. One by one the cups were then placed on the stand and any hidden baiting occurred. Each cup was placed equidistance from one another (…) in line with the holes in the Plexiglass. The occluder was then removed to reveal the cups on the stand, and any visible baiting was carried out. Once all of the cups were baited the experimenter looked away so as not to cue the monkeys, and a 5 second ‘peeking interval’ began. During the peeking interval the monkeys were able to peek both by standing up and looking down into the top compartment of the cups from above (enabling them to determine which cups contain food in the top) as well as by crouching down and looking up into the cups from below through the transparent stand (enabling them to determine which of the cups contained food in the bottom). After the 5 seconds had passed, the experimenter faced the participant and said their name followed by “choosing” to signal to the monkey that they should point to their desired cup. All of the monkeys had a large amount of previous experience with choosing cups by pointing through the respective hole. Whichever cup the monkey chose the experimenter lifted to reveal any food in the bottom compartment, and then tipped upside down to empty out any food in the top compartment. Any revealed food was then given to the monkey. If the monkey chose correctly by pointing to the double-baited cup this meant it received both a piece of date and a peanut. Choosing either of the other two cups resulted in the monkey receiving just one of the types of food. After passing the monkey the food it had won, the contents of the other two cups was revealed and moved to a discard pile.

In order to look for any strategic searching we presented the monkeys with 4 different baiting conditions; All-visible, None-visible, Bottom-only, and Top-only. In All-visible trials all the baiting occurred after the occluder had been removed so that it was in full view of the monkeys. In None-visible trials all of the baiting occurred behind the occluder so that removing the occluded started the 5 second peeking interval. In Bottom-only trials the top compartment of the cups were baited behind the occluder, and the bottom compartment was baited once the occluder was removed. Finally, for Top-only trials the bottom compartment was baited behind the occluder and the top compartment baited once the occluder was removed.

All participants received up to 8 transparent sessions followed by one opaque session. During data collection we noticed that monkeys began to peek as soon as the occluder was removed irrespective to whether baiting was complete. For this reason the monkeys all underwent a second opaque session (Opaque 2) with the table positioned far enough back that standing up or bending down would not allow them to peek into the cups during the baiting. After all baiting was complete, the table was then pushed forward to start the peeking interval. Only monkeys who passed the transparent stage were moved onto the opaque stages. In order to pass the transparent stage, monkeys had to select the correct cup a minimum of 11/16 times over 2 consecutive sessions (significantly above chance according to Binomial with chance levels of 0.33 and alpha set to 0.5). For all stages the monkeys received a maximum of 2 sessions per day, 5 days per week, with 16 trials per session. The 16 trials comprised 4 trials each of each of the different baiting conditions in a pre-determined random order.

*Coding*

For cup choice, the trials were live coded by the experimenter. Trials were coded as correct (1) if the monkey chose the target (double-baited) cup and incorrect (0) if any other cup was chosen. For each trial, the peeking was then coded from the video data. We coded the presence/absence of an above peek, and/or a below peek. Above peeking was classed as present if, during the peeking interval, the monkey stood up so that its eyes went above a predetermined critical height and looked towards the cups. The critical height was the height at which the monkey was able to see completely into the top compartment. Below peeking was classed as present if, during the peeking interval, the monkey crouched down so that its eyes could be seen below the cups, looking up towards their contents. Both types of peeking were recorded binomially and these scores used to calculate the binomial scores for “any peek” – at least one type of peeking present, and “both peek” – both types of peeking present. As mentioned above, we noticed that some of the monkeys also had a tendency to try to peek instantly after the occluder was removed and so we also coded videos for the presence/absence of any pre-peeking peeks (PPPs). PPPs were coded from the moment the occluder was removed, until the last cup was baited using exactly the same criteria as the peeking interval peeking.

A second coder scored 25% of all trials from the recorded video material to establish inter-observer reliability. Fleiss’ kappa was calculated, and according to Landis and Koch (1977), inter-observer reliability was “almost perfect” (correct choice: K=0.97, p<0.001).

*Analysis*

We looked at what proportion of trials individuals chose the correct cup (the double-baited cup) as well as what proportion of trials individuals performed the peeking behaviours for each of the different visibility conditions (Transparent, Opaque, and Opaque2). To analyse this we initially performed t-tests to look at the average scores in each visibility condition compared to chance, followed by a One-way ANOVA to look for any effect of visibility condition on cup choice. Next we ran a paired t-test to look for any significant difference in peeking between the pre-peeking peeks (PPPs) and the peeking interval peeks (PIPs). As this was not significant for all further analyses we combined the two measurements in a binomial score of any peek. We then ran a one way ANOVA to look for an effect of visibility condition on peeking. Following the t-tests we conducted multiple generalized linear mixed models (GLMMs) to further analyse the data. Following any significant results from the GLMMs we ran multiple comparison post hoc tests.

To look at any effect of visibility on the peeking frequency of the monkeys, we ran a GLMM with binomial error structure and logit link function with the proportion of trials with peeks as the DV and the test predictor variables trial number and visibility condition. The model was stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter: 0.99).

Next we were interested to look for any effect of baiting configuration on the frequency of peeking. To look at this in detail, we ran three separate GLMMs with binomial error structure and logit link function with the test predictor variables trial number and baiting configuration. For the first GLMM (GLMM2a) we used the proportion of trials with any peek as the DV, for the second GLMM (GLMM2b) we used the proportion of trials with any peek above the barrier as the DV, and for the third GLMM (GLMM2c) we used the proportion of trials with any peek below the barrier as the DV. All of the models were stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter any peek: 0.92; above peeks: 0.94; below peeks: 0.79).

Following this, we were interested to look for any effect of an interaction between the baiting configuration and the occlusion condition on the monkey’s cup choice. We ran a GLMM with binomial error structure and logit link function with cup choice (correct or incorrect) as the DV and the test predictor variables trial number and an interaction between baiting configuration and occlusion condition. The model was stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter: 1.06).

Finally, we were interested to look at the effect of peeking on cup choice. We ran one-sample t-tests to look at the average proportion of trials correct against chance when peeking had and hadn’t been performed. Then we ran a two-sample t-test to compare the average proportion of trials correct between trials where peeking had and hadn’t been performed.

**Results**

*Cup choice and peeking for each occlusion condition*

Overall, monkeys chose the correct cup significantly more often than chance in both the transparent, opaque, and opaque 2 conditions (one-sample t-tests: transparent: t(8)=14.26, p<0.001; opaque: t(8)=4.94, p=0.001; opaque 2: t(8)=4.64, p=0.002). However, there was a significant difference in the average proportion of trials correct between conditions (One-way ANOVA: F(2,24)=7.05, p=0.004), with the number of trials correct significantly higher in the transparent condition compared to the opaque and opaque 2 conditions which were not different from each other (Tukeys HSD: Transparent-Opaque: t=2.90, p=0.021; Transparent – Opaque2: t=3.52, p=0.005; Opaque – Opaque2: t=-0.62, p=0.81). Figure 2a shows the average score for each condition.

We ran a paired t-test between the proportion of trials with pre-peeking peeks (PPPs), and the proportion of trials with peek-interval peeks (PIPs) and found that these were not significantly different from each other (Paired t-test: t(26)=0.71, p=0.49). Therefore for all further analyses we combined the two measurements and used ‘any peek’. There was no significant effect of condition on the average proportion of trials where peeking occurred (One-way ANOVA: F(2,24)=2.93, p=0.07). Figure 2b shows the average proportion of trials with peeks of each kind for all conditions.

A GLMM with the presence of any peek as the dependent variable (DV), and the test predictor variables occlusion condition and trial number was significant compared to a null model lacking these test predictors (LRT: χ2=14.60, df=3, p=0.002; see table GLMM1 for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=13.23, df=2, p=0.001) with peeking significantly more common in the opaque condition compared to the transparent and opaque2 condition which were not significantly different from each other (Tukeys HSD: Transparent - Opaque: z=-4.14, p<0.001; Transparent - Opaque2: z=-1.13, p=0.49; Opaque – Opaque2: z=-3.53, p=0.001). Additionally there was a significant effect of trial number (LRT: χ2=6.01, df=1, p=0.01) with peeking decreasing with successive trials.

*Effect of baiting configurations on peeking during occluded trials*

To analyse the effect of baiting configuration on the presence of any peeking during either of the opaque trials (Opaque and Opaque2), we subset the data to remove the transparent conditions and fitted a GLMM with the presence of any peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=4.04, df=4, p=0.4; see table GLMM2a for the model output).

During test the monkeys had two different peeking locations available to them – above and below the barrier. To analyse the effect of baiting configuration on the presence of peeking above the barrier during the opaque trials we used subset of data from above and fitted a GLMM with the presence of above peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=5.27, df=4, p=0.26; see table GLMM2b for the model output).

Next, to analyse the effect of baiting configuration on the presence of peeking below the barrier during the opaque trials we again used the subset of data and fitted a GLMM with the presence of below peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=1.68, df=4, p=0.79; see table GLMM2c for the model output).

*Effects on cup choice*

To analyse the effects of visibility condition, baiting configuration, and any interaction between the two on choosing the correct cup, we fitted a GLMM with cup choice (correct or incorrect) as the DV, and the test predictor variables trial number, visibility condition, baiting configuration, and an interaction term between condition and configuration. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=22.21, df=12, p=0.035; see table GLMM3a for the model output). There was a significant effect of the interaction between visibility condition and baiting configuration (LRT:). To investigate this further we subset the data into the 3 separate visibility conditions and ran 3 separate GLMMS to look for an effect of baiting configuration on cup choice.

The GLMM for the transparent data with cup choice as the DV and the test predictor variables trial number and baiting configuration was significant when compared to a null model lacking these predictors (LRT: χ2=10.21, df=4, p=0.037; see table GLMM3b for the model output). There was a significant effect of baiting configuration (LRT: χ2=9.90, df=3, p=0.02), with Bottom-only bating leading to significantly higher rates of correct cup choice compared to All visible, and Top-only baiting, with all other configurations not different from each other (Tukey HSD: Bottom-All: z=3.64, p=0.002; Bottom-Top: z=-2.63, p=0.04; Bottom-None: z=-1.97, p=0.20; All-None: z=1.74, p=0.30; All-Top: z=0.87, p=0.82; None-Top: z=-0.81, p=0.85). Figure 3 illustrates these results.

The GLMM for the Opaque condition trials with cup choice as the DV and the test predictor variables trial number and baiting configuration was not significant when compared to a null model lacking these predictors (LRT: χ2=6.78, df=4, p=0.15; see table GLMM3c for the model output).

The GLMM for the Opaque2 condition trials with cup choice as the DV and the test predictor variables trial number and baiting configuration was not significant when compared to a null model lacking these predictors (LRT: χ2=3.32, df=4, p=0.51; see table GLMM3d for the model output).

Finally, we wanted to look for any effects of peeking on cup choice in opaque trials. In both trials where monkeys did and did not do any peeking they managed to choose the correct cup above chance (One sample t-test: No peeking: t(13)=5.57, p<0.001; Peeking: t(17)=3.02, p=0.008). However, curiously, there was a significant difference in performance between trials with and without peeks (two-sample t-test: t(22)=-3.15, p=0.005), with trials without peeks leading to better performance.

**Discussion**

The monkeys chose the correct cup (double-baited) above chance in both conditions, but performed significantly better in the transparent cup condition. Rates of peeking were significantly higher in the opaque condition compared to the transparent condition suggesting some selectivity in their information search. However, in the opaque2 condition peeking dropped back to similar levels seen in the transparent condition. This is likely due to the fact that, contrary to expectations, peeking appears to have led to lower levels of success compared to trials where there was no peeking. This will be discussed in more detail later, but the reason for this may be that when they did not peek and simply viewed the available baiting they received more information on location of the correct cup lowering the levels of chance to 50%. In most cases, in trials where they peeked, they did not fully watch the baiting as they were already peeking (PPPs) and so were not able to lower the chance levels to 50%. Additionally, seeing the food may have acted as a distractor so that the first piece of food the monkeys located whilst peeking was the cup they chose, ultimately leaving the levels of chance at 33%.

The different baiting configurations did not affect the monkeys peeking locations and we found no significant patterns which suggested they were peeking strategically. Overall, above peeks were more common and as this always enabled them to locate at least one piece of food, for most monkeys, they did not appear motivated to perform multiple peeks in order to locate a larger amount of food.

These results provide evidence that monkeys are selective about filling gaps in their knowledge – only seeking information when it is missing, however we found no evidence that their information search is strategic. In Experiment 2 we modify the set up so to eliminate the opportunity for PPPs which limit the monkeys’ ability to receive all of the desired information for each trial. Additionally we build on our results of Experiment 1 to investigate whether their ability for selective searching is a domain general ability.

**Experiment 2 – Function & food search**

When looking for food information in Experiment 1 monkeys were selective if not strategic. However to provide evidence that this is not purely a foraging strategy, in Experiment 2 the monkeys were required to search for information pertaining to the functionality of the cup as well as the location of the food. Although they use tools in the wild, capuchin monkeys are not as prevalent at tool use as the chimpanzees tested in Bohn et al.’s 2017 paradigm. Therefore we designed a new set up in which the monkeys had to search for non-food information in order to receive a food reward. In previous work (unpublished) the capuchins in this study had taken part in a study on causal understanding where they had to learnt to avoid cups with lids which trapped a food reward. 12/14 of the monkeys successfully passed this task within 10 trials, learning to avoid the cup with a lid. For the current study we adapted this task so that before selecting a cup the monkeys would have to search for information about the presence of the lid.

Additionally, in Experiment 1 we found that many of the monkeys were being to peek as soon as the occluder was removed irrespective of whether all cups were fully baited. These pre-peeking peeks (PPPs) were problematic for the monkeys as it meant that often they missed out on the information which was supposed to be available during the visible baiting (i.e. the location of some of the food rewards). This led to their peeking often being ineffective at helping them choose the correct cup, and so meant that when analysing the data we were unable to truly identify any strategic peeking due to the fact that the monkeys did not pay attention to the baiting configuration manipulation design to test this. We took this into account in Experiment 2 and modified the setup so that in all trials the peeking interval began as soon as the occluder was removed.

For this experiment we predicted that as in Experiment 1, if monkeys are selective about filling gaps in their knowledge, then they should only seek information when it is missing. Further, if monkeys are strategic about filling gaps in their knowledge then their seeking pattern should be different in trials which provide differing knowledge gaps. Finally, if monkeys’ information seeking is underpinned by a flexible, domain general metacognitive ability, then they should continue to exhibit the selective seeking patterns seen in Experiment 1, despite the search now pertaining to both food and functional information.

**Method**

*Subjects and Housing*

The same participants from Experiment 1 took part in Experiment 2. The East group received Experiment 1 followed by Experiment 2, the West group received the experiments in the reverse order to control for any priming that could have occurred.

*Setup*

The set up was very similar to Experiment 1, except that the Plexiglass panel in the door of the cubicle contained 4 evenly spaced holes rather the 3. Additionally, the transparent plastic stand onto which the cups were placed during trials was narrower to allow the use of different cups. The stand positioning was only slightly different ( ... cm away from the window) as this was the distance at which, during occluded trials, the monkeys could stand up and peek over the occluders without being able to see the reward in the bottom of the cups.

For Experiment 2, regular transparent cups with just one compartment were used. However, three different cup configurations were presented to the monkeys; All open, All baited, and Mixed. In All open trials the monkeys were presented with 4 cups *without* lids, however only one of these cups contained a reward, meaning just one cup was both open and baited. In All baited trials the monkeys were presented with 4 cups all of which contained a reward, however three of the cups were sealed with blue lids, leaving just one cup both open and baited. In Mixed trials the monkeys were presented with 4 cups; one cup without a lid, but also without a reward; one cup with a lid but which didn’t contain a reward; one cup with a lid but which did contain a reward; and one cup without a lid which did contain a reward. This meant that in every configuration there was an open-baited cup which was the correct cup to choose to obtain the food reward.

*Procedure*

All participants received up to 8 visible sessions followed by just one session of an occluded phase. Only monkeys who passed the visible stage were moved onto the occluded phase. In order to pass the visible stage, monkeys had to select the correct cup in 17/24 trials over 2 consecutive sessions (significantly above chance according to Binomial with chance at 0.25 and alpha set to 0.5). For both stages of the study monkeys received a maximum of 2 sessions per day, 5 days per week, with 12 trials per session. The 12 trials were made up of 4 trials of each configuration type presented in a pre-determined random order.

At the beginning of a trial the required cups were placed on a stand in front of the cubicle without the 4-hole Plexiglass window, so that the monkeys could see which cups were available to them for this trial, and also see the open-baited cup being baited. After baiting a large occluder (….) was positioned in front of the adjacent 4-hole window to block the monkey’s view of the second stand. The cups were then moved across from the visible stand over to the occluded stand. Each cup was placed equidistance from one another (…) in line with the holes in the Plexiglass. Once in place, the large occluder was removed and, before being allowed to choose a cup, the monkey was given a 5 second ‘peeking interval’ where the experimenter looked away. In occluded trials, before removing the large occluder, the cups were covered with small individual occluders to block the visual access to the cups once the large occluder was removed. During the peeking interval the monkeys were able to peek both by standing up and looking down on the cups from above (enabling them to determine which cups did not have lids) as well as by crouching down and looking up on the cups from below through the transparent stand (enabling them to determine which of the cups contained food). After the 5 seconds had passed, the experimenter faced the participant and said their name followed by “choosing” to signal to the monkey that they should point to their desired cup. All of the monkeys had a large amount of previous experience with choosing cups by pointing through the respective hole. If the monkey chose correctly by pointing to the open-baited cup the experimenter tipped the cup towards the monkey so it could reach in and retrieve the reward. However, if the monkey pointed to one of the incorrect cups, the experiment tipped the cup towards the monkey but either the cup contained no reward, or the blue lid blocked the monkey from retrieving the reward. The cup was then placed back on the holding stand and the experimented picked up the correct cup and tipped the reward into her own hand before placing it into a discard pile. All of the cups were then placed back onto the holding stand so that the next trial could begin. In each trial only one of the cups was correct.

*Coding*

Coding was identical to Experiment 1. Cup choice was live coded by the experimenter, with trials were coded as correct (1) if the monkey chose the target (open-baited) cup and incorrect (0) if any other cup was chosen. Peeking was then coded from the video data, with the criteria for both above and below peeks the same as in Experiment 1. As previously, both types of peeking were recorded binomially and these scores used to calculate the binomial scores for “any peek” – at least one type of peeking present, and “both peek” – both types of peeking present.

A second coder scored 25% of all trials from the recorded video material to establish inter-observer reliability. Fleiss’ kappa was calculated, and according to Landis and Koch (1977), inter-observer reliability was “almost perfect” (correct choice: K=0.97, p<0.001).

*Analysis*

Analysis followed the same procedure as Experiment 1. First, we looked at what proportion of trials individuals chose the correct cup (the open-baited cup) as well as what proportion of trials individuals performed the peeking behaviours. This was analysed by performing t-tests to look at the average scores and levels of peeking compared to chance. Multiple generalized linear mixed models (GLMMs) were then conducted to further analyse the data. Following any significant results from the GLMMs we ran further multiple comparison post hoc tests.

As in Experiment 1, we first looked for any effect of occlusion on the peeking frequency of the monkeys. We took the proportion of trials where participants peeked as our dependent variable (DV) and ran a paired t-test to look for any significant differences in peeking between visible and occluded trials. Following this, we ran a GLMM with binomial error structure and logit link function with the proportion of trials with peeks as the DV and the test predictor variables trial number and occlusion condition. The model was stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter: 0.88).

Next, to look for any effect of baiting configuration on the frequency of peeking, we ran three separate GLMMs with binomial error structure and logit link function with the test predictor variables trial number and baiting configuration. For the first GLMM (GLMM5a) we used the proportion of trials with any peek as the DV, for the second GLMM (GLMM5b) we used the proportion of trials with peeks above the barrier as the DV, and for the third GLMM (GLMM5c) we used the proportion of trials with peeks below the barrier as the DV. All of the models were stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter any peek: 0.4; above peeks: 0.41; below peeks: 0.7).

Following this, to look for any effect of an interaction between the baiting configuration and the occlusion condition on the monkey’s cup choice, we ran a GLMM with binomial error structure and logit link function with cup choice (correct or incorrect) as the DV and the test predictor variables trial number and an interaction between baiting configuration and occlusion condition. The model was stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter: 0.99). To follow up on the results of this GLMM we performed two further GLMMs to look at the effects of baiting configuration for visible and occluded trials separately. Firstly we split the data into the two occlusion conditions and then for each condition ran a separate GLMM with binomial error structure and logit link function with cup choice (correct or incorrect) as the DV and the test predictor variables trial number and baiting configuration. Both of the models were stable for all fixed effects and overdispersion appeared to be no issue (dispersion parameter occluded: 1.02; visible: 0.94).

Finally, we were interested to look at the effect of peeking of cup choice. We ran one-sample t-tests to look at the average proportion of trials correct against chance when peeking had and hadn’t been performed. Then we ran a two-sample t-test to compare the average proportion of trials correct between trials where peeking had and hadn’t been performed.

**Results**

*Cup choice and peeking for each occlusion condition*

Overall, monkeys chose the correct cup significantly more often than chance in both the visible and occluded conditions (one-sample t-tests: visible: t(15)=28.77,p<0.001; occluded: t(15)=4.57,p<0.001). However, there was a significant difference in the proportion of trials correct between conditions (paired t-test: t(15)=-10.61,p<0.001), as well as the proportion of trials where peeking occurred (paired t-test: t(15)=9.61,p<0.001). All these results are clearly demonstrated in Figure 4.

We fitted a GLMM with the presence of any peeks as the dependent variable (DV), and the test predictor variables occlusion condition and trial number. The model was significant compared to a null model lacking these test predictors (LRT: χ2=23.46, df=2, p<0.001; see table GLMM4 for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=23.077, df=1, p<0.001) with peeking being much more frequent in the occluded condition.

*Effect of baiting configurations on peeking during occluded trials*

To analyse the effect of baiting configuration on the presence of any peeking behaviour during the test trials (occluded trials) we subset the data into occlusion conditions and using only data from the occluded trials fitted a GLMM with the presence of any peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=5.18, df=3, p=0.16; see table GLMM5a for the model output).

During test the monkeys had two different peeking locations available to them – above and below the barrier. To analyse the effect of baiting configuration on the presence of peeking above the barrier during the test trials (occluded trials) we used only data from the occluded trials and fitted a GLMM with the presence of above peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=1.74, df=3, p=0.63; see table GLMM5b for the model output).

Then, to analyse the effect of baiting configuration on the presence of peeking below the barrier during the test trials (occluded trials) we used only data from the occluded trials and fitted a GLMM with the presence of below peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=3.86, df=3, p=0.28; see table GLMM5c for the model output).

*Effects on cup choice*

To analyse the effects of occlusion condition, baiting configuration, and any interaction between the two on choosing the correct cup, we fitted a GLMM with cup choice (correct or incorrect) as the DV, and the test predictor variables trial number, occlusion condition, baiting configuration, and an interaction term between condition and configuration. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=37.62, df=6, p<0.001; see table GLMM6a for the model output). There was a significant effect of an interaction between occlusion condition and baiting configuration on selecting the correct cup (LRT: χ2=6.64, df=2, p=0.036).

To investigate this interaction further, we again subset the data into occlusion conditions and fitted two separate GLMMs with cup choice (correct or incorrect) as the DV, and the test predictor variables baiting configuration and trial number for data from each of the occlusion conditions. The model for the occluded trials was not significant when compared to a null model lacking these test predictors (LRT: χ2=1.92, df=3, p=0.59; see table GLMM6b for the model output).

However the model for the visible trials was significant when compared to the null model lacking these test predictors (LRT: χ2=23.99, df=3, p<0.001); see table GLMM6c for the model output), with a significant effect of baiting configuration on cup choice (LRT: χ2=21.71, df=2, p<0.001). Following this significant result we ran pairwise comparisons for the 3 baiting configurations and found that the all open configuration led to a significantly higher proportion of correct trials than the other two baiting configurations, which were not different from each other (all open –all baited: z=-5.81, p<0.001; all open – mixed: z=-3.79, p<0.001; all baited –mixed: z=-2.33,p=0.05).

Finally, we wanted to look for any effects of peeking on cup choice. In trials where monkeys did not peek they did not manage to choose the correct cup above chance (One-sample t-test: t(7)=-0.13,p=0.90). In contrast, in trials where monkeys did peek, they did manage to choose the correct cup above chance (One-sample t-test: t(15)=2.83,p=0.01). Overall, there was a significant difference in the proportion of trials correct between trials with and without peeking (two-sample t-test: t(15)=9.54,p<0.001).

**Discussion**

The monkeys chose the correct cup (open-baited) above chance in both conditions, but performed significantly better in the visible condition. Their peeking showed selectivity as the rates of peeking were significantly higher in the opaque condition and the presence of peeking significantly affected their cup choice leading to greater success. These results provide evidence that capuchin monkey’s ability to seek information selectively is a flexible, domain general ability as they selectively sought information about the function of the cups rather than about the location of food. However, as cup configuration had no effect on the monkey’s pattern of peeking, in line with our finding in Experiment 1, we found no evidence that the monkeys fill gaps in their knowledge strategically.

**General Discussion and Conclusions**

* Summarise result

In both experiments the capuchins predominantly searched for information in trials in which it was missing, successfully providing evidence for a domain general selective search strategy. However, the monkeys failed to show any strategic searching, suggesting that they have only a basic form of this metacognitive ability.

* Discuss prediction 1 (Monkeys are selective)

Our first prediction was that if monkeys are selective about filling gaps in their knowledge, then they should only seek information when it is missing. This prediction was supported as in both experiments the rates of peeking were significantly higher in the occluded/opaque conditions (Experiment 1: ….; Experiment 2: ….)

* Discuss prediction 2 (Strategic peeking)

Secondly, we predicted that if monkeys are strategic about filling gaps in their knowledge then their seeking pattern should be different in trials which provide differing knowledge gaps. We found no evidence to support this prediction as ……

* Discuss prediction 3 (domain general ability)

Finally, we predicted that if monkeys’ information seeking is underpinned by a flexible, domain general metacognitive ability, then they should exhibit similar seeking patterns for both food (Experiment 1) and functional information (Experiment 2). This prediction was also supported as the selectivity seen in the capuchins was clear for both experiments…….

* Discuss problems

Experiment 1 PPP was a BIG problem and led to peeks being uninformative/ food is a distractor

Above peeks are easier….

* Summary and Conclusions

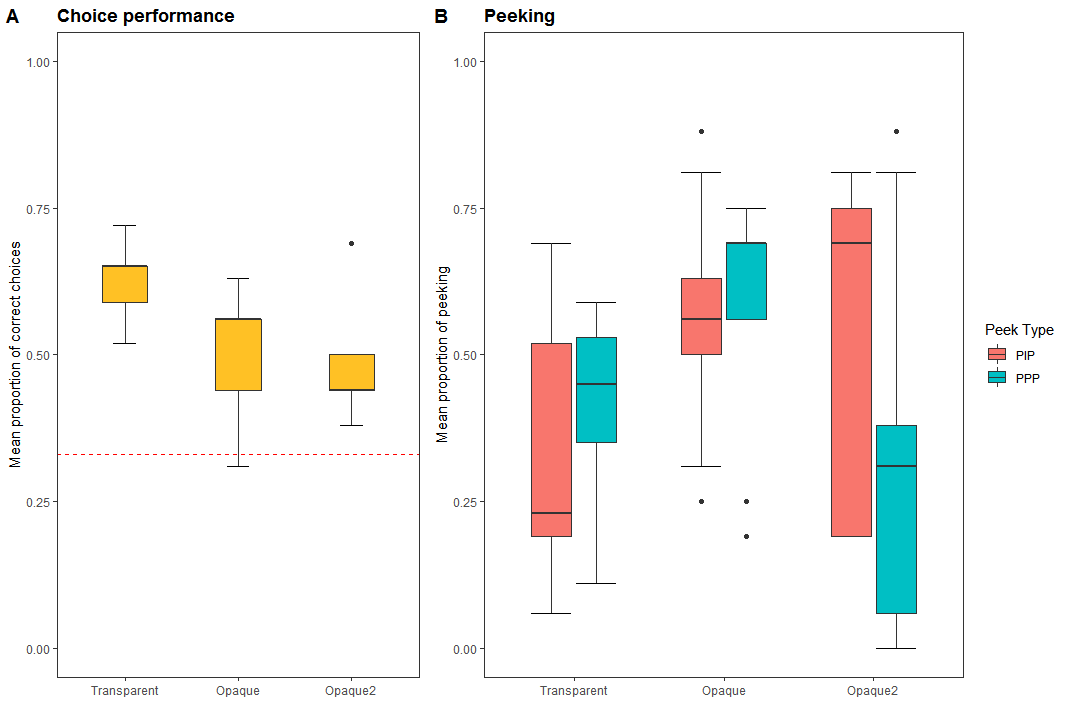
Monkeys are selective but not strategic, in the right set up their search can be shown to be flexible and domain general.

Figures and Tables

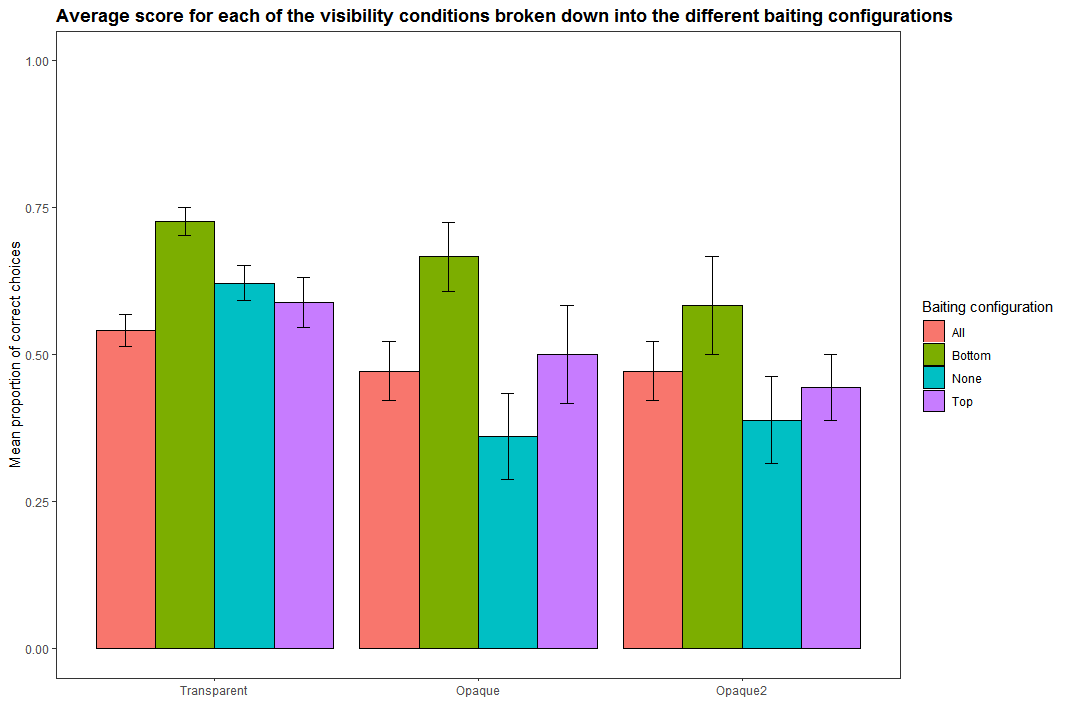
**Figure 1.** Cup diagram

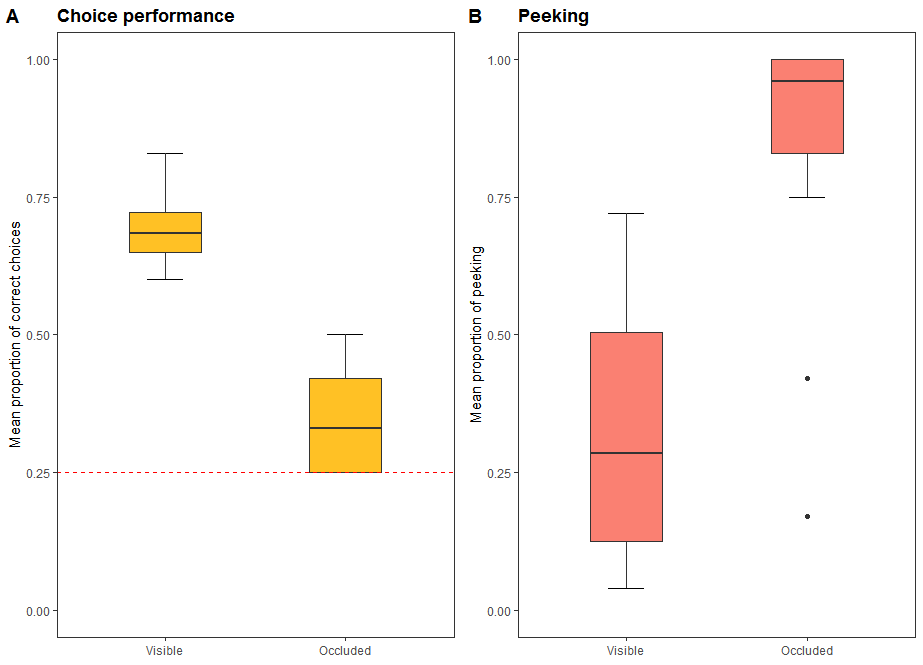
TBA.

**Figure 2.** Choice performance and peeking rates in Experiment 1.

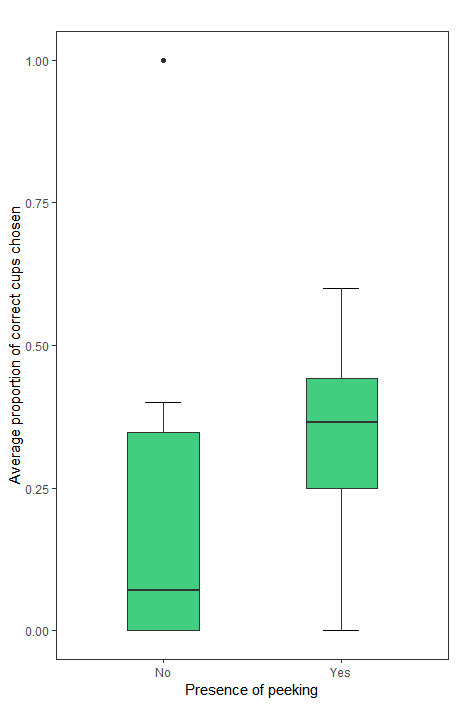


**Figure 3.** Interaction between visibility and baiting in double cylinders  
error bars show mean +/- se.



**Figure 4.** Choice performance and peeking rates in Experiment 2.

**Figure 5.** Peeking effect on cup choice in Lids



**Table 1.** GLMM1 output showing the effect of the three visibility conditions on the presence of any peeks.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visiblea |  |  |  |  |  |  |  |
| Visibilty condition: Opaque2a |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

**Table 2.** GLMM2 outputs showing the effect of baiting configuration on any peeks during both opaque trials.

1. GLMM2a output showing the effect of baiting configuration on any peek type.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

1. GLMM2b output showing the effect of baiting configuration on above peeks only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

1. GLMM2c output showing the effect of baiting configuration on below peeks only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

**Table 3.** GLMM3 outputs showing the effect of an interaction between visibility conditions and baiting configuration.

1. GLMM3a output showing the effect of an interaction between all three visibility conditions and baiting configuration.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visible |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-only |  |  |  |  |  |  |  |
| Baiting configuration: None-visible |  |  |  |  |  |  |  |
| Baiting configuration: Top-only |  |  |  |  |  |  |  |
| Trial number |  |  |  |  |  |  |  |
| Visible condition & Bottom-only |  |  |  |  |  |  |  |
| Visible condition & None |  |  |  |  |  |  |  |
| Visible condition & Top-only |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

1. GLMM3b output showing the effect of baiting configuration on Transparent trials only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visible |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-only |  |  |  |  |  |  |  |
| Baiting configuration: None-visible |  |  |  |  |  |  |  |
| Baiting configuration: Top-only |  |  |  |  |  |  |  |
| Trial number |  |  |  |  |  |  |  |
| Visible condition & Bottom-only |  |  |  |  |  |  |  |
| Visible condition & None |  |  |  |  |  |  |  |
| Visible condition & Top-only |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

1. GLMM3c output showing the effect of baiting configuration on Opaque trials only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visible |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-only |  |  |  |  |  |  |  |
| Baiting configuration: None-visible |  |  |  |  |  |  |  |
| Baiting configuration: Top-only |  |  |  |  |  |  |  |
| Trial number |  |  |  |  |  |  |  |
| Visible condition & Bottom-only |  |  |  |  |  |  |  |
| Visible condition & None |  |  |  |  |  |  |  |
| Visible condition & Top-only |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

1. GLMM3d output showing the effect of baiting configuration on Opaque2 trials only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visible |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-only |  |  |  |  |  |  |  |
| Baiting configuration: None-visible |  |  |  |  |  |  |  |
| Baiting configuration: Top-only |  |  |  |  |  |  |  |
| Trial number |  |  |  |  |  |  |  |
| Visible condition & Bottom-only |  |  |  |  |  |  |  |
| Visible condition & None |  |  |  |  |  |  |  |
| Visible condition & Top-only |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM1 consisted of … trials from 9 monkeys.

**Table 4**. GLMM4 showing the effect of occlusion condition on the presence of peeking during the Lids task.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 2.97 | 0.75 |  |  |  |  |  |
| Visibility condition: Visiblea | -3.79 | 0.69 | -5.48 | 1 | < 0.01 |  |  |
| Trial numberb | -0.08 | 0.09 | -0.87 | 1 | 0.38 |  |  |

Notes: Reference category: aOccluded. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMM4 consisted of … trials from … monkeys.

**Table 5.** GLMM5 outputs showing the effect of cup configuration on any peeks during occluded trials in the Lids task.

1. GLMM5a output showing the effect of cup configuration on any peek type.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 3.95 | 1.38 |  |  |  |  |  |
| Cup configuration: All Opena | 0.83 | 1.30 | 0.64 | 1 | 0.52 |  |  |
| Cup configuration: Mixeda | -0.48 | 1.03 | -0.47 | 1 | 0.64 |  |  |
| Trial numberb | 1.33 | 0.81 | 1.65 | 1 | 0.10 |  |  |

Notes: Reference category: aAll baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM5a consisted of … trials from … monkeys.

1. GLMM5b output showing the effect of baiting configuration on above peeks only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 3.36 | 1.49 |  |  |  |  |  |
| Cup configuration: All-Opena | 0.30 | 1.07 | 0.28 | 1 | 0.78 |  |  |
| Cup configuration: Mixeda | -0.56 | 1.03 | -0.54 | 1 | 0.59 |  |  |
| Trial numberb | 0.71 | 0.75 | 0.95 | 1 | 0.34 |  |  |

Notes: Reference category: aAll baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM5b consisted of … trials from … monkeys.

1. GLMM5c output showing the effect of baiting configuration on below peeks only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -2.51 |  |  |  |  |  |  |
| Cup configuration: All Opena | 1.45 | 0.92 | 1.58 | 1 | 0.11 |  |  |
| Cup configuration: Mixeda | 0.76 | 0.93 | 0.81 | 1 | 0.42 |  |  |
| Trial numberb | -0.04 | 0.31 | -0.14 | 1 | 0.89 |  |  |

Notes: Reference category: aAll baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM5c consisted of … trials from … monkeys.

**Table 6.** GLMM6 outputs showing the effect of an interaction between occlusion condition and cup configuration.

1. GLMM6a output showing the effect of an interaction between occlusion condition and cup configuration.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -0.84 | 0.28 |  |  |  |  |  |
| Visibility condition: Visiblea | 1.03 | 0.31 | 3.32 | 1 | >0.01 |  |  |
| Cup configuration: All-openb | 0.38 | 0.38 | 0.99 | 1 | 0.32 |  |  |
| Cup configuration: Mixedb | 0.37 | 0.38 | 0.98 | 1 | 0.33 |  |  |
| Trial number | -0.12 | 0.07 | -1.63 | 1 | 0.10 |  |  |
| Visible condition & All-open | 1.15 | 0.47 | 2.46 | 1 | 0.01 |  |  |
| Visible condition & Mixed | 0.12 | 0.44 | 0.26 | 1 | 0.79 |  |  |

Notes: Reference category: aOccluded, b All baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM6a consisted of … trials from … monkeys.

1. GLMM6b output showing the effect of cup configuration on Visible trials only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -0.87 | 0.28 |  |  |  |  |  |
| Cup configuration: All-opena | 0.39 | 0.38 | 1.03 | 1 | 0.30 |  |  |
| Cup configuration: Mixeda | 0.39 | 0.38 | 1.03 | 1 | 0.30 |  |  |
| Trial number | -0.12 | 0.18 | -0.68 | 1 | 0.50 |  |  |

Notes: Reference category: aAll baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM6b consisted of … trials from … monkeys.

1. GLMM6c output showing the effect of cup configuration on Occluded trials only.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 0.19 |  |  |  |  |  |  |
| Cup configuration: All-opena | 1.53 | 0.26 | 5.81 | 1 | >0.01 |  |  |
| Cup configuration: Mixeda | 0.49 | 0.21 | 2.33 | 1 | 0.02 |  |  |
| Trial number | -0.12 | 0.08 | -1.43 | 1 | 0.15 |  |  |

Notes: Reference category: aAll baited. The covariate trial number was z-transformed to a mean of zero and a standard deviation of one. The sample for GLMM6c consisted of … trials from … monkeys.

**Appendix**

**Double-cylinders Paired t-test effect of condition on cup choice. Opaque 2 excluded**

With Opaque2 excluded, there was a significant effect of visibility condition on monkeys’ cup choice (Paired t-test: t(8)=-3.44, p=0.009).

**Double-cylinders ANOVA condition effect on peeking PIPs and PPPs separately**

No significant effect of condition on the average proportion of trials where peeking occurred during the 5 second peeking interval (PIPs), where peeking occurred before the peeking interval (PPPs), (One-way ANOVAs: PIP: F(2,24)=3.26, p=0.06; PPP: F(2,24)=2.38, p=0.11)

**Double-cylinders Paired t-tests effect of condition on peeking. Opaque2 is excluded: any peek, PIPs and PPPs**

If we exclude Opaque 2 then we find a significant effect of visibility condition on all 3 measurements for peeking (Paired t-tests: any peek: t(8)=4.26, p=0.003; PIPs: t(8)=3.98, p=0.004; PPPs: t(8)=2.83, p=0.02).

1. **Double-cylinders GLM visibility effect on peeking. All 3 visibility conditions: PIPs and PPPs.**

PIPs

A GLMM with the presence of any PIPs as the dependent variable (DV), and the test predictor variables occlusion condition and trial number was significant compared to a null model lacking these test predictors (LRT: χ2=13.04, df=3, p=0.005; see AppendixTable1a for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=11.76, df=2, p=0.003) with peeking being much less frequent in the transparent condition compared to either of the opaque conditions which were not different from each other (Tukeys HSD: Transparent - Opaque: z=-4.30, p<0.001; Transparent - Opaque2: z=-3.88, p<0.001; Opaque – Opaque2: z=0.02, p=0.99). Additionally, there was a significant effect of trial number (LRT: χ2=6.91, df=1, p=0.009), with peeks decreasing slightly over trials.

PPPs

A GLMM with the presence of any PPPs as the dependent variable, and the same test predictors as above was also significant compared to a null model lacking these test predictors (LRT: χ2=8.21,df=3, p=0.042; see AppendixTable1b for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=7.94, df=2, p=0.02) with PPPs being much more frequent in the opaque condition compared to both the transparent and opaque2 conditions which were not different from each other (Tukeys HSD: Transparent – Opaque: z=-3.02, p=0.006; Transparent – Opaque2: z=1.09, p=0.51; Opaque – Opaque2: z=-2.46, p=0.03).

1. **Double-cylinders GLM visibility effect on peeking. Opaque2 excluded: Any peeks, PIPS and PPPs.**

Any Peeks  
When Opaque2 data was excluded from the dataset, a GLMM with the presence of any peeks as the dependent variable (DV), and the test predictor variables occlusion condition and trial number was significant compared to a null model lacking these test predictors (LRT: χ2=13.04, df=2, p=0.001; see AppendixTable2a for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=12.04, df=1, p<0.001) with peeking being significantly more common in the Opaque condition compared to the transparent condition.

PIPs   
When Opaque2 data was excluded from the dataset, a GLMM with the presence of PIPs as the dependent variable (DV), and the test predictor variables listed above was significant compared to a null model lacking these test predictors (LRT: χ2=13.36, df=2, p=0.001; see AppendixTable2b for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=10.38, df=1, p=0.001) with peeking being significantly more common in the Opaque condition compared to the transparent condition. Additionally, trial number had a significant effect on peeking with peeking decreasing across trials (LRT: χ2=5.31, df=1, p=0.02).

PPPs   
When Opaque2 data was excluded from the dataset, a GLMM with the presence of PPPs as the dependent variable (DV), and the test predictor variables listed above was significant compared to a null model lacking these test predictors (LRT: χ2=7.03, df=2, p=0.03; see AppendixTable2b for the model output). Occlusion condition was a significant predictor for the presence of peeking (LRT: χ2=6.38, df=1, p=0.012) with peeking being significantly more common in the Opaque condition compared to the transparent condition.

1. **Double-cylinders GLM baiting effect on peeking. All 3 visibility conditions: PIPS and PPPs.**

PIPs

To analyse the effect of baiting configuration on the presence of any peeking behaviour during the 5 second peeking interval of the test trials (opaque trials) we subset the data into visibility conditions and using only data from the opaque trials (Opaque & Opaque2), we fitted a GLMM with the presence of any peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=14.45, df=4, p=0.006; see AppendixTable3a for the model output). Baiting configuration was a significant predictor for the presence of peeking (LRT: χ2=14.18, df=3, p=0.003), with peeking being significantly more common when no baiting was visible (None-visible) compared to any of the other configurations which were not different from each other (Tukey HSD: All-Bottom: z=0.43,p=0.97; All-Top: z=1.98,p=0.19; Bottom-Top: z=1.51,p=0.43; All-None: z=4.63,p<0.001; Bottom-None: z=4.14,p<0.001; Top-None:z=-3.20,p=0.008).

PPPs

Using only data from the opaque trials (Opaque & Opaque2), we analysed the effect of baiting configuration on the presence of pre-peeking-interval peeks during the test trials (opaque trials). We fitted a GLMM with the presence of any PPPS as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=14.78, df=4, p=0.005; see AppendixTable3b for the model output). Baiting configuration was a significant predictor for the presence of peeking (LRT: χ2=14.74, df=3, p=0.002), with peeking being significantly less common when no baiting was visible (None-visible) compared to any of the other configurations which were not different from each other (Tukey HSD: All-Bottom: z=0.80,p=0.85; All-Top: z=0.22,p=0.99; Bottom-Top: z=-0.58,p=0.94; All-None: z=-4.28,p<0.001; Bottom-None: z=4.79,p<0.001; Top-None:z=4.39,p<0.001).

1. **Double-cylinders GLM baiting effect on peeking. Opaque2 excluded (Opaque only): Any peeks, PIPs and PPPs.**

Any Peeks

With data from Opaque trials excluded, we looked for any effect of baiting configuration on the presence of any peek type. A GLM was fitted with the presence of any peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=6.69, df=4, p=10.15; see AppendixTable4a for the model output).

PIPs

With data from Opaque trials excluded, we looked for any effect of baiting configuration on the presence of any type of peek during the 5 second peeking interval. A GLM was fitted with the presence of any peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The null model did not converge. But the model was significant when compared to a null model lacking these test predictors (LRT: χ2=16.86, df=4, p=0.002; see AppendixTable4b for the model output). Baiting configuration had a significant effect on peeking (LRT: χ2=10.94, df=3, p=0.01), with more peeking taking place when no baiting was visible (None-visible), however this was no significant according to a post hoc test (Tukey HSD: All-Bottom: z=0.08,p=1; All-Top: z=1.26,p=0.56; Bottom-Top: z=1.03,p=0.70; All-None: z=1.98,p=0.17; Bottom-None: z=1.98,p=0.17; Top-None: z=-1.76,p=0.26).

PPPs

With data from Opaque2 trials excluded, we looked for any effect of baiting configuration on the presence of any type of pre-peeking-interval peek (PPP). PPPs are not possible in the None-visible baiting configuration of Opaque trials as the peeking interval begins as soon as the excluder is removed. Therefore for this analysis the None-visible configuration was also removed from the dataset. A GLM was fitted with the presence of any PPP as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significantly different from a null model lacking these predictors (LRT: χ2=2.87, df=3, p=0.41; see AppendixTable4c for the model output).

1. **Double-cylinders GLM baiting effect on above peeks only. All 3 visibility conditions: PIPs and PPP.**

PIPs

To analyse the effect of baiting configuration on the presence of above peeks only during the 5 second peeking interval of the test trials (opaque trials) we subset the data into visibility conditions and using only data from the opaque trials (Opaque & Opaque2), we fitted a GLMM with the presence of above peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=17.31, df=4, p=0.002; see AppendixTable5a for the model output). Baiting configuration was a significant predictor for the presence of peeking (LRT: χ2=15.69, df=3, p=0.001), with peeking being significantly more common when no baiting was visible (None-visible) compared to any of the other configurations which were not different from each other (Tukey HSD: All-Bottom: z=-0.08,p=0.99; All-Top: z=1.11,p=0.68; Bottom-Top: z=1.16,p=0.65; All-None: z=4.42,p<0.001; Bottom-None: z=4.48,p<0.001; Top-None:z=-4.27,p<0.001).

PPPs

Using only data from the opaque trials (Opaque & Opaque2), we analysed the effect of baiting configuration on the presence of pre-peeking-interval peeks during the test trials (opaque trials). We fitted a GLMM with the presence of any PPPS as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=14.36, df=4, p=0.006; see AppendixTable5b for the model output). Baiting configuration was a significant predictor for the presence of peeking (LRT: χ2=14.58, df=3, p=0.002), with peeking being significantly less common when no baiting was visible (None-visible) compared to any of the other configurations which were not different from each other (Tukey HSD: All-Bottom: z=0.21,p=0.99; All-Top: z=-0.61,p=0.92; Bottom-Top: z=-0.83,p=0.83; All-None: z=-2.88,p=0.02; Bottom-None: z=-2.98,p<0.01; Top-None:z=2.76,p=0.03).

1. **Double-cylinders GLM baiting effect on above peeks only. Opaque2 excluded: Any peeks, PIPs, PPPs.**

Any peeks

To analyse the effect of baiting configuration on the presence of any peeking above the barrier during the test trial (opaque trials) we used only data from the opaque trial and fitted a GLMM with the presence of above peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking the predictors (LRT: χ2=7.52, df=4, p=0.11; see AppendixTable6a for the model output).

PIPs

To analyse the effect of baiting configuration on the presence of peeking above the barrier during the 5 second peeking interval of the test trials (opaque trials) we used only data from the opaque trials and fitted a GLMM with the presence of above peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was significant when compared to a null model lacking these test predictors (LRT: χ2=15.47, df=4, p=0.004; see AppendixTable6b for the model output). The likelihood of peeking above was significantly affected by the baiting configuration (LRT: χ2=12.28, df=3, p=0.006) with peeking above being more common when none of the baiting was visible. Following this significant result we ran pairwise comparisons for the 4 baiting configurations and found that there was no significant difference in rates of above peeks between any of the configurations (all – bottom: z=0.231,p=0.995; all – top: z=-1.013, p=0.714; bottom – top: z=-0.871, p=0.798; all – none: z=-2.108, p=0.129; bottom – none: z=-2.174, p=0.111; top – none: z=-1.895, p=0.201)

PPPs

As mentioned in 4.c. PPP isn’t possible in the none-visible baiting configurations of opaque trials and so as before we used the subset of data without the non-visible baiting configuration. We ran a GLMM with the same test predictors as above, but with the dependent variable set to the presence of above pre-peeking peeks (PPPs) for opaque trials only. The model was not significant when compared to a null model lacking the predictors (LRT: χ2=5.08, df=3, p=0.17; see AppendixTable6c for the model output).

1. **Double-cylinders GLM baiting effect on below peeks only. All 3 visibility conditions: PIPs and PPP.**

PIPs

To analyse the effect of baiting configuration on the presence of below peeks only during the 5 second peeking interval of the test trials (opaque trials) we subset the data into visibility conditions and using only data from the opaque trials (Opaque & Opaque2), we fitted a GLMM with the presence of below peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=5.08, df=4, p=0.28; see AppendixTable7a for the model output).

PPPs

Using only data from the opaque trials (Opaque & Opaque2), we analysed the effect of baiting configuration on the presence of pre-peeking-interval peeks during the test trials (opaque trials). We fitted a GLMM with the presence of any PPPS as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=2.70, df=4, p=0.61; see AppendixTable7b for the model output).

1. **Double-cylinders GLM baiting effect on below peeks only. Opaque2 excluded: Any peeks, PIPs, PPPs.**

Any peeks

To analyse the effect of baiting configuration on the presence of any peeking below the barrier during the test trial (opaque trials) we used only data from the opaque trial and fitted a GLMM with the presence of below peeks as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking the predictors (LRT: χ2=1.82, df=4, p=0.77; see AppendixTable8a for the model output).

PIPs

To analyse the effect of baiting configuration on the presence of peeking below the barrier during the 5 second peeking interval of the test trials (opaque trials) we used only data from the opaque trials and fitted a GLMM with the presence of below peeks during the 5 second peeking interval as the dependent variable (DV), and the test predictor variables baiting configuration and trial number. The model was not significant when compared to a null model lacking these test predictors (LRT: χ2=1.32, df=4, p=0.86; see table GLMM2ci for the model output).

PPPs

As mentioned in 4.c. and 6.c. PPP isn’t possible in the none-visible baiting configurations of opaque trials and so as before we used the subset of data without the none-visible baiting configuration. We ran a GLMM with the same test predictors as above, but with the dependent variable set to the presence of above pre-peeking peeks (PPPs) for opaque trials only. The model was not significant when compared to a null model lacking the predictors (LRT: χ2=2.70, df=3, p=0.44; see AppendixTable8c for the model output).

1. **Double-cylinders GLM Visibility and Baiting interaction on cup choice. Opaque2 excluded**

After excluding the Opaque2 data, we fitted a GLMM with cup choice (correct or incorrect) as the DV, and the test predictor variables trial number, visibility condition, baiting configuration, and an interaction term between condition and configuration. The model was significant when compared to a null model lacking these predictors (LRT: χ2=16.63, df=8, p=0.03; see AppendixTable9a for the model output). The drop1 analysis didn’t show any significant terms in the model, however plotting the data suggests there may be an effect of an interaction. Therefore we subset the data back into the separate visibility conditions and ran two further GLMs. These are shown in the main text.

1. **Double-cylinders t-tests peeking effect on cup choice. Both opaque trials: PIPs and PPPs.**

PIPs

For peeking during the 5 second peeking interval, monkeys choose above chance for both trials with and without peeks (One-sample t-test: No peeking: t(17)=4.76,p<0.001; Peeking: t(17)=2.55,p=0.02). However, there was no significant difference between performance in peeking vs no-peeking trials (Two-sample t-test: t(32)=-0.82,p=0.42).

PPPs

Interestingly, for pre-peeking-interval peeking, monkeys chose above chance in trials where they did not peek (One-sample t-test: No peeking: t(17)=3.11,p=0.006), but chose at chance in trials where they did peek (One-sample t-test: Peeking: t(17)=2.55,p=0.02). However, there was no significant difference between performance in peeking vs no-peeking trials (Two-sample t-test: t(33)=-0.81,p=0.42).

1. **Double-cylinder t-tests peeking effect on cup choice, Opaque2 excluded: Any peek, PIPs, and PPPs.**

Any peek

Overall, for any peek type, both trials with and without peeks monkeys chose the correct cup above chance (One sample t-tests: No peeks: t(5)=6.38, p=0.001; Peeks: t(8)=2.55, p=0.03). However, there was a significant difference in performance between trials with monkeys performing better in trials without peeks compared to trials with peeks (Two-sample t-test: t(8)=-4.38,p=0.002).

PIPs

For peeking during the 5 second peeking interval, monkeys did not choose above chance for either trials with or without peeks (One-sample t-test: No peeking: t(8)=2.35,p=0.047; Peeking: t(8)=1.54,p=0.16). Additionally, there was no significant difference between performance in peeking vs no-peeking trials (Two-sample t-test: t(16)=-0.63,p=0.54).

PPPs

For pre-peeking-interval peeks, monkeys chose above chance both when they did and did not peek (One-sample t-test: No peeking: t(8)=3.02,p=0.017; Peeking t(8)=3.87,p=0.005), with no significant difference in performance between peeking and no-peeking trials (Two-sample t-test: t(16)=0.15,p=0.88).

**Appendix tables**

**AppendixTable1.** GLMMA1 outputs showing the predictors for the effect of visibility on peeking using all 3 visibility conditions.

1. GLMMA1a output showing the predictors for PIPs

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visiblea |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

1. GLMMA1b output showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visiblea |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys

**AppendixTable2.** GLMMA2 outputs showing the predictors for the effect of visibility on the presence of peeks with Opaque2 excluded.

* 1. GLMMA2a output showing the predictors for any peek.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Visibility condition: Visiblea |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

* 1. GLMMA2b output showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | |
| (Intercept) | 0.25 | 0.28 |  |  |  |  |  |
| Visibility condition: Visiblea | -1.23 | 0.28 | -4.32 | 1 | < 0.01 |  |  |
| Trial numberb | -0.19 | 0.08 | -2.48 | 1 | 0.02 |  |  |

* 1. GLMMA2c output showing the predictors for the presence of PPPs.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | P | 95% confidence Interval | | |
| (Intercept) | 0.36 | 0.30 |  |  |  | |  |  |
| Visibility condition: Visiblea | -0.81 | 0.27 | -3.02 | 1 | < 0.01 | |  |  |
| Trial numberb | -0.05 | 0.07 | -0.70 | 1 | 0.48 | |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable3.** GLMMA3 outputs showing the predictors for the effect of baiting configuration on all peeks with all 3 visibility conditions.

1. GLMMA3a outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

1. GLMMA3b showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable4.** GLMMA4 outputs showing the predictors for the effect of baiting configuration on all peeks with Opaque 2 excluded.

1. GLMMA4a outputs showing the predictors for any peeks.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

1. GLMMA4a outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -0.77 | 0.53 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 0.05 | 0.67 | 0.08 | 1 | 0.94 |  |  |
| Baiting configuration:  None-visiblea | 6.66 | 3.36 | 1.98 | 1 | 0.05 |  |  |
| Baiting configuration:  Top-onlya | 0.75 | 0.60 | 1.26 | 1 | 0.21 |  |  |
| Trial numberb | -0.53 | 0.30 | -1.77 | 1 | 0.08 |  |  |

1. GLMMA4a outputs showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 1.85 | 0.84 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 0.92 | 0.76 | 1.22 | 1 | 0.22 |  |  |
| Baiting configuration:  None-visiblea | -23.79 | 6204.46 | -0.004 | 1 | 0.99 |  |  |
| Baiting configuration:  Top-onlya | -0.12 | 0.69 | -0.18 | 1 | 0.86 |  |  |
| Trial numberb | -0.57 | 0.33 | -1.71 | 1 | 0.09 |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable5.** GLMMA5 outputs showing the predictors for the effect of baiting configuration on above peeks only with all 3 visibility conditions.

1. GLMMA5a outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | Df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

1. GLMMA5b outputs showing the predictors for PPPs**.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | Df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable6**. GLMMA6 outputs showing the predictors for the effect of baiting configuration on above peeks with Opaque 2 excluded.

1. GLMMA6a outputs showing the predictors for any peeks.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | Df | p | 95% confidence Interval | |
| (Intercept) |  |  |  |  |  |  |  |
| Baiting configuration: Bottom-onlya |  |  |  |  |  |  |  |
| Baiting configuration:  None-visiblea |  |  |  |  |  |  |  |
| Baiting configuration:  Top-onlya |  |  |  |  |  |  |  |
| Trial numberb |  |  |  |  |  |  |  |

1. GLMMA6b outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | Df | p | 95% confidence Interval | |
| (Intercept) | -1.35 | 0.66 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | -0.22 | 0.96 | -0.23 | 1 | 0.818 |  |  |
| Baiting configuration:  None-visiblea | 6.99 | 3.32 | 2.11 | 1 | 0.035 |  |  |
| Baiting configuration:  Top-onlya | 0.72 | 0.71 | 1.01 | 1 | 0.311 |  |  |
| Trial numberb | -0.51 | 0.35 | -1.47 | 1 | 0.141 |  |  |

1. GLMMA6c outputs showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | 1.36 | 0.89 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 1.44 | 1.16 | 1.24 | 1 | 0.21 |  |  |
| Baiting configuration:  None-visiblea | -23.32 | 1146.25 | -0.02 | 1 | 0.98 |  |  |
| Baiting configuration:  Top-onlya | -0.18 | 0.80 | -0.23 | 1 | 0.82 |  |  |
| Trial numberb | -0.75 | 0.42 | -1.78 | 1 | 0.07 |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable7.** GLMMA7 outputs showing the predictors for the effect of baiting configuration on below peeks with all 3 visibility conditions.

1. GLMMA7a outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -7.08 | 4.73 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 1.66 | 4.59 | 0.36 | 1 | 0.72 |  |  |
| Baiting configuration:  None-visiblea | 3.86 | 5.08 | 0.76 | 1 | 0.45 |  |  |
| Baiting configuration:  Top-onlya | 2.99 | 4.13 | 0.72 | 1 | 0.47 |  |  |
| Trial numberb | 0.36 | 0.74 | 0.49 | 1 | 0.62 |  |  |

1. GLMMA7a outputs showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -7.08 | 4.73 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 1.66 | 4.59 | 0.36 | 1 | 0.72 |  |  |
| Baiting configuration:  None-visiblea | 3.86 | 5.08 | 0.76 | 1 | 0.45 |  |  |
| Baiting configuration:  Top-onlya | 2.99 | 4.13 | 0.72 | 1 | 0.47 |  |  |
| Trial numberb | 0.36 | 0.74 | 0.49 | 1 | 0.62 |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable8.** GLMMA8 outputs showing the predictors for the effect of baiting configuration on below peeks with Opaque 2 excluded.

1. GLMMA6a outputs showing the predictors for any peeks.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -7.08 | 4.73 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 1.66 | 4.59 | 0.36 | 1 | 0.72 |  |  |
| Baiting configuration:  None-visiblea | 3.86 | 5.08 | 0.76 | 1 | 0.45 |  |  |
| Baiting configuration:  Top-onlya | 2.99 | 4.13 | 0.72 | 1 | 0.47 |  |  |
| Trial numberb | 0.36 | 0.74 | 0.49 | 1 | 0.62 |  |  |

1. GLMMA6b outputs showing the predictors for PIPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -7.08 | 4.73 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | 1.66 | 4.59 | 0.36 | 1 | 0.72 |  |  |
| Baiting configuration:  None-visiblea | 3.86 | 5.08 | 0.76 | 1 | 0.45 |  |  |
| Baiting configuration:  Top-onlya | 2.99 | 4.13 | 0.72 | 1 | 0.47 |  |  |
| Trial numberb | 0.36 | 0.74 | 0.49 | 1 | 0.62 |  |  |

1. GLMMA6c outputs showing the predictors for PPPs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -1.84 | 0.77 |  |  |  |  |  |
| Baiting configuration: Bottom-onlya | -3.03 | 1.85 | -1.64 | 1 | 0.10 |  |  |
| Baiting configuration:  None-visiblea | -22.53 | 9285.48 | -0.002 | 1 | 0.99 |  |  |
| Baiting configuration:  Top-onlya | -1.37 | 1.29 | -1.06 | 1 | 0.29 |  |  |
| Trial numberb | 0.44 | 0.39 | 1.11 | 1 | 0.27 |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.

**AppendixTable9.** GLMM3 outputs showing the predictors for the effect of an interaction between baiting configuration and visibility condition on peeking with Opaque2 excluded.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Estimate | SE | Χ2 | df | p | 95% confidence Interval | |
| (Intercept) | -0.11 | 0.35 |  |  |  |  |  |
| Visibility condition: Visible | 0.25 | 0.40 | 0.64 | 1 | 0.52 |  |  |
| Baiting configuration: Bottom-only | 0.81 | 0.50 | 1.62 | 1 | 0.11 |  |  |
| Baiting configuration: None-visible | -0.47 | 0.51 | -0.93 | 1 | 0.36 |  |  |
| Baiting configuration: Top-only | 0.11 | 0.57 | 0.20 | 1 | 0.84 |  |  |
| Trial number | 0.03 | 0.07 | 0.40 | 1 | 0.69 |  |  |
| Visible condition & Bottom-only | -0.03 | 0.57 | -0.04 | 1 | 0.97 |  |  |
| Visible condition & None | 0.83 | 0.55 | 1.50 | 1 | 0.13 |  |  |
| Visible condition & Top-only | 0.08 | 0.65 | 0.13 | 1 | 0.90 |  |  |

Notes: Reference category: a Opaque. The covariates trial number was z-transformed to a mean of zero and a standard deviation of one. The sample of GLMMA2 consisted of 1120 trials from 9 monkeys.