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Disentangling Great Apes' Decoy-Effect Bias in a Food Choice Task

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Abstract – The decoy effect is a violation of rationality that occurs when the relative preference between two target options changes with the addition of a third option, called the decoy, that is no better than the target options but worse than one of the options on one attribute. The presence of the decoy increases the chance that the option that dominates it on this attribute is chosen over the other target option. The current study tested decoy effects with great apes' food preferences. We presented apes with two target items, grape and banana, and a third item, the decoy, which was either a smaller grape or a smaller piece of banana. We found that apes' decisions were not influenced by the presence of a decoy. In general, apes did not increase their choices in favor of the target item that dominated the decoy. This would indicate that great apes are not vulnerable to the cognitive biases that cause decoy effects in humans, at least in cases where choice is between two different types of food. We discuss what can be concluded about the psychological causes of human irrational choices and their evolutionary origin.

Keywords – Decoy-effect, Rationality, Great apes, Food preferences

Utility theory predicts that preferences among different items are independent of external alternatives. In particular, the addition of an inferior option to a choice set should not increase the probability of selecting an option from the original set (*c.f.* the principle of regularity (Huber, Payne, & Puto, 1982; Luce, 1959)). However, humans constantly violate this assumption of rationality. A well-known example of irrational bias in human choices is the decoy effect (Ariely & Wallsten, 1995; Huber et al., 1982). This occurs when the relative preference between two targets changes with the addition of a third target which is no better than the two target options, and objectively worse than one option on one attribute. For instance, imagine someone trying to decide between two smart-phones taking into account price and battery life. The choice-set is:

Option A: expensive, long battery life
Option B: affordable, short battery life

When presented with this choice-set, people will choose Option A with probability *p* and they would therefore choose Option B with probability 1-*p*. However, let the choice-set include a further option Option C, which is no better than Option A or Option B on either attribute but more expensive than Option A.

Option C: very expensive, long battery life

If the probability of choosing Option A in this new choice-set increases, then there is a decoy effect. Several explanations have been proposed to elucidate why decoys affect decision-making in humans. One prominent explanation is that the effect is driven by a need for justification while making choices. People would favor the item that dominates the decoy because it is easy to explain why this item is better (Mercier & Sperber, 2011; Shafir, Simonson, & Tversky, 1993; Simonson, 1989). Another explanation is that decoy effects are a consequence of loss aversion: the effect results from a change in the reference point of a prospect theory value function (Kahneman & Tversky, 1979). That is, the presence of the decoy situates the reference point as having the decoy rather than as having nothing. Thus, having less of what the decoy provides induces an important loss of utility. Finally, decoys could result from a process of constructing preferences, in particular, from weighting the dimension made salient by the decoy more strongly than other dimensions (Ariely & Wallsten, 1995; Slovic, 1995). Making one dimension more relevant than the others facilitates selecting out one option: the decoy is strictly dominated on this dimension and should not be chosen.

While the mechanisms underlying decoy effects are still under debate, the phenomenon has also been documented in a variety of decision-making tasks in humans (Slaughter, Kausel, & Quiñones, 2011; Trueblood, Brown, Heathcote, & Busemeyer, 2013; Zhen & Yu, 2016) and several nonhuman species including starlings (Bateson, 2002), honeybees and gray jays (Shafir, Waite, & Smith, 2002), túngara frogs (Lea & Ryan, 2015), and primates such as macaques and capuchin monkeys (Parrish, Afrifa, & Beran, 2018; Parrish, Evans, & Beran, 2015; but also see Cohen & Santos, 2017). Primate studies have used visual perceptual tasks in which subjects must distinguish between items of the same type varying in perceptual features, with conflicting findings (Cohen & Santos, 2017; Parrish et al., 2015). In these tasks, a monkey is presented with a pair of stimuli, for instance, two rectangular shapes of the same size varying in their orientation (vertical and horizontal). A decoy is introduced in the form of a smaller version of one of the two rectangles. If the decoy works, the rectangle matching the orientation of the decoy should increase its probability to be chosen in relation to a baseline condition with just two rectangles. In addition, a recent study used a representational task to investigate decoy effects on rhesus monkeys (Parrish et al., 2018). The researchers presented monkeys with two different icons referring to two different computerized tasks (a matching-to-sample task and a psychomotor cursor-tracking task) to assess which task they would select as a baseline preference. Then, they introduced the decoy versions for both tasks. These decoys took longer to complete but were otherwise identical to the original tasks. Although macaques learned to perform well in all four tasks, the decoy versions did not influence their selection rates of two original tasks in relation to their baseline preferences (e.g., they were not more likely to select the icon for the matching-to-sample task in comparison with the psychomotor task when the third option was the more time consuming decoy version of matching-to-sample task).

The current study tests great apes (henceforth apes). It investigates preferences as revealed by free choices between food items: pieces of grapes, bananas and carrots. We use this methodology because we know apes have food preference and care about what type of food they can consume (Hanus & Call, 2007; Hopper, Egelkamp, Fidino, & Ross, 2018; Sánchez-Amaro, Peretó, & Call, 2016). Our study aims to complement the mixed results obtained from previous studies (Cohen & Santos, 2017; Parrish et al., 2015, 2018) and, more importantly, is designed to answer whether choice of preferred items rather than visual features (e.g., objects displayed in different orientations) would lead to a decoy effect. Indeed, evidence of decoy effects in humans cannot be explained by strictly perceptual processes only since, in experiments with humans, the choice-set is often presented verbally and can consist of options of varying personal preference among humans (Huber et al., 1982; Sedikides, Ariely, & Olsen, 1999; Simonson, 1989). This study with apes is also more comparable with previous preferential choice tasks with nonhumans (Bateson, 2002; Bateson, Healy, & Hurly, 2003; Schuck-Paim, Pompilio, & Kacelnik, 2004). Finally, the preferential choice task is a paradigm that has ecological validity, since primates' choices of food in their everyday lives vary and is directly associated with fitness costs and benefits (Gilby & Wrangham, 2007; Janmaat, Polansky, Ban, & Boesch, 2014).

We presented apes with binary and trinary choices using different food items to investigate whether they were susceptible to the decoy effect. In the first phase of the study, we established individual preferences by presenting a binary choice between items that varied in terms of quality and quantity. In the second phase, we presented apes with trinary choices to test the effect of different decoys. Additionally, we administered a trinary control to rule out the possibility that the change in the preferred items between binary and trinary choices was merely due to the increase in the number of options. We expected that apes would choose more often the option that dominated the decoy during test trials compared to binary and trinary controls.

Method

Subjects

We tested 32 apes housed at the WKPRC in Leipzig Zoo: 7 bonobos (5 females; M_{age} = 18.3 years, SD_{age} = 8.6 years); 14 chimpanzees (7 females; M_{age} = 27.4 years, SD_{age} = 14.2 years); 3 gorillas (2 females; M_{age} = 15.6, SD_{age} = 2.9 years); 8 orangutans (5 females; M_{age} = 19.3 years, SD_{age} = 9.7 years). Apes came from five social groups: one bonobo group, two chimpanzee groups, one gorilla group and one orangutan group. Groups were housed in indoor enclosures with access to outdoor areas. Apes were tested individually in their sleeping rooms. All individuals had access to water *ad libitum* and were never food deprived. Their diet consisted of regular mixtures of fruits, vegetables and animal protein. Their diet included the types of food we used in this study. Table 1 has information about the subjects.

Materials

We used a sliding platform attached to a Plexiglass panel installed on the front side of the apes' enclosure (Figure 1). The platform could be slid forward towards the panel, which had three equidistant holes on its bottom part (one on each corner and a third one in the middle). There were three different food rewards: whole (B; 2-3 cm length and 2 cm diameter approximately) and half banana slices (b), whole grapes (G) and half grapes (g), and carrot slices (C; same size as B).

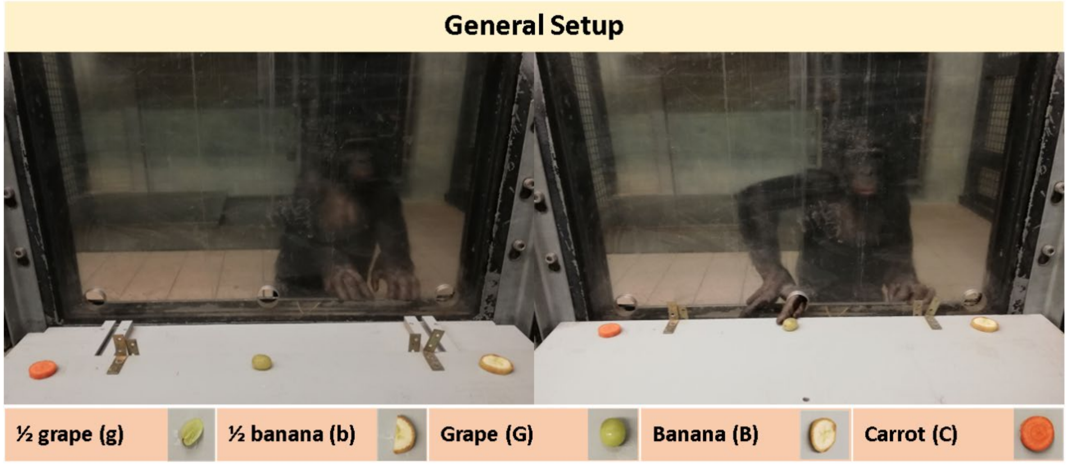

Figure 1. Representation of the setup.

Table 1

Data Summary of the Most Important Conditions

Name	Species	Sex	Age	Grapes/Bananas chosen in GBg trials (12 max)	Grapes/Bananas chosen in GBb trials (12 max)	Grapes/Bananas chosen in GB trials (12 max)	Grapes/Bananas chosen in GBC trials (12 max)	Fisher exact Test (GB vs GBC)
Fimi	Bonobo	female	9	11/1	12/0	11/1	11	$p > .05$
Gemena	Bonobo	female	12	12/0	11/1	9/3	12/0	$p > .05$
Lexi	Bonobo	female	18	1/11	0/12	0/12	8/4	$p = .001$
Luiza	Bonobo	female	13	12/0	11/1	9/3	12/0	$p > .05$
Yasa	Bonobo	female	20	12/0	10/2	10/2	11/1	$p > .05$
Joey	Bonobo	male	35	10/2	12/0	12/0	12/0	$p > .05$
Kuno	Bonobo	male	21	12/0	11/1	12/0	12/0	$p > .05$
Daza	Chimpanzee	female	32	10/1	9/2	8/4	8/3	$p > .05$
Dorien	Chimpanzee	female	37	8/4	10/2	11/1	11/1	$p > .05$
Fraukje	Chimpanzee	female	42	12/0	12/0	9/3	12/0	$p > .05$
Frederike	Chimpanzee	female	44	8/2	8/3	7/5	11/1	$p > .05$
Jeudi	Chimpanzee	female	52	4/2	7/2	5/7	7/5	$p > .05$
Sandra	Chimpanzee	female	25	12/0	10/2	8/4	12/0	$p > .05$
Tai	Chimpanzee	female	15	11/1	4/8	6/6	11/1	$p > .05$
Alex	Chimpanzee	male	17	12/0	12/0	9/3	12/0	$p > .05$
Bangolo	Chimpanzee	male	8	12/0	11/1	8/4	12/0	$p > .05$
Frodo	Chimpanzee	male	24	11/0	11/1	8/4	12/0	$p > .05$
Kofi	Chimpanzee	male	12	8/4	10/1	10/2	4/8	$p = .03$
Lobo	Chimpanzee	male	14	10/2	7/5	11/1	10/2	$p > .05$
Lome	Chimpanzee	male	16	11/1	8/4	6/6	7/5	$p > .05$
Robert	Chimpanzee	male	42	7/5	6/6	11/1	12/0	$p > .05$
Kibara	Gorilla	female	14	4/8	1/10	3/9	6/6	$p > .05$
Kumili	Gorilla	female	14	1/11	1/11	1/11	4/8	$p > .05$
Abeeko	Gorilla	male	19	3/9	0/10	0/12	4/8	$p > .05$
Dokana	Orangutan	female	29	10/0	11/1	6/6	10/2	$p > .05$
Padana	Orangutan	female	20	11/1	6/6	3/9	11/1	$p = .003$
Pini	Orangutan	female	29	9/3	9/3	5/7	5/7	$p > .05$
Raja	Orangutan	female	14	10/0	10/1	8/4	8/4	$p > .05$
Tanah	Orangutan	female	8	7/1	9/3	11/1	7/4	$p > .05$
Batak	Orangutan	male	8	5/3	6/5	6/6	8/3	$p > .05$
Bimbo	Orangutan	male	37	7/0	12/0	7/5	12/0	$p = .037$
Suaq	Orangutan	male	9	6/0	11/1	6/6	8/4	$p > .05$

Note. Grey represent the 4 individuals that were excluded from the analysis. Yellow represents the 9 individuals with clear preferences for one of the two items.

Design and Procedure

At the beginning of a session, the experimenter (E) sat in front of the platform. To start a trial, E retracted the platform and covered it with a plastic lid—preventing apes from seeing the platform's surface. Depending on the condition, E baited the platform by placing the two or three food items in front of the holes on the panel. Once the food items were in place, E removed the lid and pushed the platform towards the panel. While pushing the platform, the experimenter had his eyes closed and his head oriented straight. We considered a choice when an ape touched a food item through the hole, pointed at it or put her mouth next to the hole. If apes chose two different food items simultaneously, E retracted the platform and repeated the procedure. After the ape obtained the selected item, E retracted the platform and prepared the next trial.

Each ape received seven types of trials (see Table 2) across seven sessions. Each session included 12 trials. E presented each type of trial in six different configurations—counterbalancing the locations of the food items. Every configuration was randomly presented twice across sessions. The first three sessions included baseline trials as well as control for decoy trials (3 types of trials within a session). The next three sessions included control for preference trials as well as decoy test trials (3 types of trial within a session). Either between the two sets of sessions (session 4) or at the end of the test (session 7), apes received one session consisting of 12 low value baseline trials.

Table 2

Summary of the Trials and its Rationale

Types of trials	Food options	Rationale for the session
Baseline	BG	Establishing baseline preference
Low value baseline with strictly dominated option	BGC	Establishing baseline preference with three options. The carrot option is strictly dominated by the other two options. The idea is that Baseline and Baseline with strictly dominated option should not differ. See Table 2.
Control for preference	BGG or BBG	Controlling for the reliability of the preference measure (i.e. whether the addition of the same item—not a decoy version of it—changes their decision. Not used in analysis.
Control for decoy	Bb	Controlling that b is dominated by B
Control for decoy	Gg	Controlling that g is dominated by G
Test for decoy effect with b	BGb	Testing whether the presence of b increases the probability of choosing B
Test for decoy effect with g	BGg	Testing whether the presence of g increases the probability of choosing G

Analyses

Before we analyzed the data, we assessed whether the choices expressed in the binary sessions revealed stable preferences by comparing how often a food item was chosen in the binary baseline (*BG*) with the low-value baseline (*BGC*). Fischer exact tests (see Table 1) revealed that 4 individuals significantly changed their preference during testing between the two equivalent conditions (since *C* does not qualify as a decoy). Hence, they were excluded from further analyses.

We analyzed the data in two ways. First, we built two generalized linear mixed models (GLMM) (Baayen, Davidson, & Bates, 2008) with binomial error structure to investigate whether apes chose *B* or *G* differently across conditions. Model 1 evaluated whether apes' choices towards *B*—in comparison to all other possible choices—were significantly influenced by the condition. That is, between baseline preference trials (*BG*), test trials (*BGb*) and low value baseline trials (*BGC*). Model 2 used the same approach to investigate whether *G* was chosen differently between conditions. In a further *post-hoc* analysis, we analyzed whether those individuals (N = 19) with no statistically significant preference for any item (i.e., when selecting either *B* or *G* less than 10 times in *BG* trials and less than eight times in *BGC* trials) were still affected by decoys.

Second, in a *post-hoc* analysis we calculated whether apes' choices significantly deviated between decoy test trials (*BGb* and *BGg*) and *BGC* trials as a function of the decoy presented. To do so, we calculated a preference ratio $\frac{B}{B+G}$ for every subject for *BGb*, *BGg* and *BGC* trials. Next, we compared the ratios obtained from *BGb* and *BGg* trials to those obtained from *BGC* trials. In contrast to the GLMMs, these ratio calculations disregarded the number of times *b* or *g* were preferred and allowed us to directly compare the relative preference for the target items. Furthermore, these analyses allowed us to single out the response of each individual while downplaying the contribution of potential outliers (i.e., apes that showed different preferences between the binary baseline and the low-value baseline).

Results

Apes preferred grapes over bananas in most choices (61% in *BG* trials, 70% in *BGb* trials*,* 73% in *BGg* trials and 79% in *BGC* trials; $N = 28$). See details in Table 1. The GLMMs did not document a decoy effect. We found no significant differences in the proportion of times apes chose *B* across *BG*, *BGb* and *BGC* conditions (GLMM: $c^2 = 2.6$, $df = 2$, $p = .27$, $N = 1{,}008$). Additionally, we found no significant differences in the proportion of times that apes chose *G* across *BG*, *BGg* and *BGC* conditions (GLMM: $c^2 =1.8$, $df = 2$, $p = .40$, $N =1{,}008$). See the Appendix for model details. Furthermore, in a post-hoc analysis we inspected whether individuals with no statistically significant preference ($N = 19$) were affected by decoys. As in our previous analysis, we found no significant differences in the proportion of times apes chose B or G across test and baseline conditions (see Appendix for model results). The results of the above analyses were likely determined by a few individuals whose choices were going contrary to the prediction of a decoy effect—they chose G more often when the decoy *b* was present. We therefore decided to run a *post hoc* analysis that takes each subjects' sensitivity to the decoy option as the element of statistical analysis, while the above models pooled together all subjects' choices.

For each subject, we calculated the 'relative preference for *B* over *G*' (i.e., $\frac{B}{B+G}$). We then compared the relative preferences in the baseline session *BGC* and in the decoy trials *BGb* and *BGg*. A significant increase in the number of choices of *B* in the *b* decoy trials could be interpreted as documenting a decoy effect, and so would a significant increase in the number of choices of *G* in the *g* decoy trials.

The mean value of $\frac{B}{B+G}$ was higher in *BGb* compared to *BGC* (*BGb* $M = 0.27$, $SD = 0.29$; *BGC* $M = .19$, $SD = 0.22$), but this difference was not significant ($t(27) = 1.77$; $p = .09$). Apes did not choose *B* more often in *BGC* compared to *BGg* (*BGC* $M = 0.19$, $SD = 0.22$; *BGg* $M = 0.17$, $SD = 0.25$) ($t(27) = 0.63$; $p = .53$). Given these results, we cannot conclude that the apes' decisions were affected by decoys.

Discussion

We found no compelling evidence that apes were susceptible to decoy effects when presented with different food choices varying in quantity and quality. Although including b as a choice slightly enhanced the preference for B over G, these differences were not statistically significant.

The two most probable explanations for the results are (a) that nonhuman apes are not sensitive to decoy options when choosing their preferred item from a set of options, and (b) that there is a sensitivity to decoy, which we failed to measure because preferences among food items can vary importantly across individuals and also across time within subjects. Our second statistical analysis controls for the individual variation since it excluded four individuals that varied their choices (and presumably their preference) over time. Still, seven individuals varied their choices substantially between BG and BGC trials. Relatedly, we found that only nine of 28 apes showed a clear preference for one of the items (21% of chimpanzees, no orangutans, 66% of gorillas and 57% of bonobos). One possible solution to this problem is to establish a very high preference for one of the items as baseline (see Parrish et al., 2018). However, the downside of this approach is that strong preferences might be too hard to override regardless of other contextual features (e.g., decoy options). A thorough investigation of option (b) would thus require either a sample size that is difficult to obtain, or a totally different methodology. In that sense, one possible avenue for future research could be the use of touch-screen methods to establish food preferences. This way, subjects would be better able to evaluate the options presented. They would avoid prepotent responses, and hence reduce variation in choices (see Hopper et al., 2018, for an implementation of this methodology). Nonetheless, our findings might tip the balance in favor of considering that nonhuman primates are not sensitive to decoy when their preferences are at stake (option a). There are, indeed, reasons why the decoy effect would be a marker of human specific cognitive processes.

One of the main explanations of the decoy effect in humans is that it is driven by a need for self-justification while making choices (Mercier & Sperber, 2011; Shafir et al., 1993; Simonson, 1989). People would favor the item that dominates the decoy because it is easy to explain why this item is better. To our knowledge, no study has shown that apes justify their choices in front of others. For instance, when chimpanzees choose one partner over another to fulfil a collaborative goal, there are no behavioral signs of justifying a decision for an audience (Bullinger, Melis, & Tomasello, 2011; Melis, Hare, & Tomasello, 2006), and they do not attempt to manage their own reputations in view of others (Engelmann, Herrmann, & Tomasello, 2012) although in the wild great apes vocalize differently depending on the audience (see Clay & Zuberbühler, 2012; Slocombe & Zuberbühler, 2007).

The decoy effect can also be explained as a consequence of loss aversion if the decoy changes the reference point of a prospect theory value function (Kahneman & Tversky, 1979). In our study, the presence of the banana decoy situates the reference point as having the decoy rather than as having nothing. Thus, having less of what the decoy provides induces an important loss of utility (i.e., the presence of the banana decoy increases the difference in utility between not having anything and having at least the decoy quantity of banana). Therefore, with the presence of the decoy, choosing grape implies forbearing the gain in utility of choosing an item that is at least as good as the banana decoy. Yet, this loss of utility is less likely to be compensated by the utility gained from taking the grape. The utility maximizer is therefore more likely to take the big slice of banana. In our study, however, apes still preferred the grape in most of trials. One possibility is that prospect theory does not clarify the underlying mechanisms that would drive individuals' decisions in these contexts (i.e., under what conditions and how the presence of the decoy influence the reference point). It is possible that the reference point is changed only when subjects consider the reasons of their choices or are trying to justify their choices. If that is the case, then nonhumans are unlikely to modulate their reference point with the presence of decoys.

Decoys can also help in the process of constructing a preference (Ariely & Wallsten, 1995). The presence of the decoy makes one dimension more salient than others. Explained as a consequence of processes for construal preferences, the decoy results from weighting the dimension made salient by the decoy more strongly than other dimensions (Ariely & Wallsten, 1995). This dimension is made salient because it easily allows selecting out one option: the decoy is strictly dominated on this dimension and should not be chosen. In our case, the banana decoy allows one to easily select out the bigger banana slice. Indeed, more than half of the apes in our sample increased their choices towards banana. However, this effect was not generalizable and thus we cannot conclude that this mechanism underlies decoy effects in apes. A plausible interpretation of the results is again that this preference construal is triggered by a search for justifications, which does not occur with great apes.

However, in view of the evidence that nonhumans are sometimes sensitive to decoy stimuli (Parrish et al., 2015) in other kinds of tests, it is probable that several processes have decoy effects as consequences. Selective attention and visual perception are good candidate processes that could affect both humans and nonhumans. For instance, biases in visual perception could explain the perceptual decoy effect already documented in other primates (Parrish et al., 2015, but see Cohen & Santos, 2017). In our study, such a bias would have resulted in apes over-estimating the size of the banana slices or the grapes in the presence of their respective decoys. To better assess this possibility future studies could combine features from perceptual decoy tasks (e.g., Parrish et al., 2015) with natural food choices. For example, by presenting similar food items (e.g., pellets of different colors and tastes) varying in spatial configuration.

If the decoy effect were to appear in nonhumans tested in tasks other than perceptual ones, one should consider the possibility that this effect may not be caused by a single mechanism. Future studies should then be focused on targeting and specifying the mechanisms that are hypothesized to produce the effect.

In summary, our results show that, with regards to the decoy effect, nonhuman apes might be more rational than humans, at least in the context of choosing among food items. Pointing out that some types of irrational choices are human specific provides very relevant information for understanding the cognitive basis of such choices. In the case of the decoy effect, two mechanisms hypothesized to be responsible for the effect are likely to be human specific. The first mechanism is a preference: the desire to feel justified. It leads to making 'reason-based choice' (Shafir et al., 1993). The second mechanism is the capacity to elaborate reasons for making one's choice: it is sensitive to the presence of the decoy, which is used for elaborating reasons in favor of choosing the decoyed item. Ultimately, these findings (and previous ones: Agrillo, Parrish & Beran, 2014; Jensen, Call & Tomasello, 2007) serve to cast some doubts on the idea that human reasoning invariably issues nothing but rational choices. In fact, the decoy effect might be a signature of human reasoning together with the confirmation bias (Mercier & Sperber, 2011). This account of at least one type of irrational choices goes against the idea that human cognition is less error prone than nonhuman cognition because it is supplemented by reason –an idea that remains popular among philosophers and behavioral economists (see Mercier & Sperber, 2017, for a review).

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Ethics Statement and Competing Interests

The study was approved by an internal ethics committee at the Max Planck Institute and it complies with the Weatherfall report "The use of nonhuman primates in research", the 'EAZA Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria' and the 'WAZA Ethical Guidelines for the Conduct of Research on Animals by Zoos and Aquariums'.

The authors declare no competing interests.

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Appendix

Reliability scores

20% of the trials were coded by the second author, blinded to the baseline preferences of subjects. Inter-coder reliability was very high (Cohen's K = .993, $p < .001$ – percentage of agreement was 99).

Model analysis

All model analyses were run using R statistics (version 3.1.1) and the package "lme4." To rule out collinearity we checked the variance inflation factors (VIF) of the model. All VIF values were closer to 1 with the exception of Session which was closer to 2.

Two generalized linear mixed models (GLMMs) were used to investigate ape's likelihood to choose B or G across different conditions. To obtain the P values for the individual fixed effects we conducted likelihood-ratio tests.

Model 1: Banana model

Model 1 investigated whether apes varied in their relative preference for B over other options across preference trials (BG), decoy trials (BGb) and low-value trials (BGC). If individuals were influenced by the presence of a decoy, we would expect a significant increase in their choices towards B during decoy trials. The model included 1008 trials. The full model included the test variable condition (3 levels: preference trial, decoy trial and low-value trial. The control variables were trial, session, position of the baseline (either before or after test sessions) and specie as fixed effects; subject, center and left location of rewards as random effects and all possible random slopes. The comparison between the full and the null model was not significant (GLMM: $\chi^2 = 2.6$, df = 2, $p = .27$, N = 1,008).

Model 2: Grape model

Model 2 investigated whether apes varied in their relative preference for G over other options across preference trials (BG), decoy trials (BGg) and low-value trials (BGC). If individuals were influenced by the presence of a decoy, we would expect a significant increase in their choices towards G during decoy trials. The model included 1008 trials. The full model included the test variable condition (3 levels: preference trial, decoy trial and low-value trial. The control variables were trial, session, position of the baseline (either before or after test sessions) and specie as fixed effects; subject, center and left location of rewards as random effects and all possible random slopes. The comparison between the full and the null model was not significant (GLMM: $\chi^2 = 1.8$, df = 2, $p = .41$, N = 1,008).

Post-hoc model analysis

Individuals with no preference (models 3 and 4)

We inspected whether individuals with no clear preference for one specific item in both GB trials (selecting less than 10 times the same food choice) and in GBC trials (selecting less than 8 times the same food choice). For that purpose, we subset the datasets of models 1 and 2.

Model 3: Banana model, no a priori preferences.

The subset of model 1 included 684 trials from 19 individuals. The comparison between the full and the null model was not significant (GLMM: $\chi^2 = 3.97$, df = 2, $p = .14$, N = 684).

Model 4: Grape model, no a priori preferences.

Similarly, the subset of model 2 included 684 trials from 19 individuals. The comparison between the full and the null model was not significant (GLMM: $\chi^2 = 3.71$, df = 2, $p = .16$, N = 684).