The Psychological Record (2021) 71:133–141
https://doi.org/10.1007/s40732-020-00404-3

ORIGINAL ARTICLE

Negative Behavioral Contrast in Capuchin Monkeys (*Sapajus sp.*)

Ana Paula Rocha[1] · **Marilia Pinheiro de Carvalho**[1] · **Soraya Tavares**[1] · **François Tonneau**[1]

Abstract

A capuchin monkey will accept a preferred food in exchange for tokens if a conspecific also exchanges tokens for the preferred food; but he will reject a less-preferred food if the conspecific exchanges tokens for preferred food. These rejections are usually interpreted as a case of an inequity aversion based on a precursor of a sense of justice. An alternative hypothesis proposes that it is the contrast between the types of food reinforcement experienced by the subject throughout the task that affects the reinforcing function of the less-preferred food. The present study tested this hypothesis with three conditions. Capuchin monkeys received cucumbers (the less-preferred food) as the reinforcer in a token-exchange task during the first and third conditions, and received grapes (the preferred food) in the second condition. The difference in the proportions of acceptances between the first and the third conditions provided evidence of negative contrast in this species, a type of contrast that can at least partially account for the rejections documented in the inequity-aversion literature.

Keywords Negative contrast · Capuchin monkeys (*Sapajus sp.*) · Inequity aversion · Frustration

When people perceive that their inputs/outcomes are unequal to the inputs/outcomes of another individual, they try to reestablish equity (Adams, 1963; Adams & Rosenbaum, 1962). For instance, employees that perceive their job benefits as lesser than those of a coworker who occupies the same position and works equally well might ask the manager for more benefits or might reduce their productivity so that the inequity of outcomes with respect to the coworker decreases (Adams, 1963). This phenomenon has been termed *inequity aversion* (Fehr & Schmidt, 1999) and has also been documented in nonhuman animals such as capuchin monkeys (Brosnan & de Waal, 2003, 2006; Dindo & de Waal, 2007; Dubreuil, Gentile, & Visalberghi, 2006; Fletcher, 2008; Fontenot, Watson, Roberts, & Miller, 2007; Leimgruber, Rosati, & Santos, 2016; Takimoto, Kuroshima, & Fujita, 2010; Talbot et al., 2017; van Wolketen, Brosnan, & de Waal, 2007)—even though the evidence is mixed in this species (Roma et al., 2006; McAuliffe et al., 2015; Sheskin et al., 2014; Silberberg, Crescimbene, Addessi, Anderson, & Visalberghi, 2009).

The seminal work on inequity aversion with capuchin monkeys had the subjects exchanging tokens for food (Brosnan & de Waal, 2003). The animals (hereafter: Monkeys A and B) worked in pairs, in adjacent chambers that allowed them to see their partner performing the task and receiving food. The type of food that a monkey received varied across four conditions: in the Equity condition, both monkeys received a less-preferred food (cucumber slices); in the Inequity condition, Monkey A received cucumbers and Monkey B received a preferred food (grapes); in the Effort Control condition, Monkey A received cucumbers in exchange for the tokens and Monkey B received grapes "for free" without having to exchange tokens; in the Food Control condition, Monkey A received cucumbers for the tokens but Monkey B was not present and grapes were deposited in the empty adjacent chamber. Each monkey experienced each condition twice, one as Monkey A and the other as Monkey B. At issue was whether rejecting to exchange tokens and/or to take the less-preferred food varied across conditions while an animal performed the Monkey-A role.

The average proportion of cucumber rejections equaled .05 in the Equity condition and did not differ from the proportion of rejections routinely observed in the group of animals being tested. However, average proportion of rejections was markedly higher in the other three conditions (.45 in Inequity, .80 in Effort Control, and .48 in Food Control), and could not be accounted for by the intrinsic value of cucumber as an appetitive stimulus (Brosnan & de Waal, 2003). The authors suggested that monkeys A rejected the cucumbers because they were averse to the inequity between their receiving the less-preferred food for exchanging tokens while their partners received the preferred food for the same task.

At least three explanatory hypotheses have been put forward to account for the rejections. The first, as mentioned, proposes that

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✉ Marilia Pinheiro de Carvalho
marilia.pinheiro.carvalho@gmail.com

[1] Federal University of Pará, Belém, Brazil

the capuchin monkeys are inequity averse and that their rejections reflect a precursor of a sense of justice (Fehr & Schmidt, 1999). Inequity aversion could also explain the difference in the proportion of rejections between the Effort Control (.80) and Food Control (.48) conditions because only in the former did the partners differ in the food they received. This hypothesis is both empirically and theoretically disputed. Heinrich (2004), for example, argued that an inequity-aversion account of the rejections is flawed because rejecting the less-preferred food only increases inequity among partners, instead of reducing it.

According to the second hypothesis, the monkeys rejected the less-preferred food because they were frustrated (e.g., Price, 2014; Roma et al., 2006). Because the animals participated as both Monkey A and Monkey B, their experience with the preferred food when they played the Monkey-B role created an expectation that this was the reinforcer to exchange for the tokens. This expectation was frustrated when the monkeys received the less-preferred food while playing the Monkey-A role, hence the cucumber rejections. This account is corroborated by the similar proportions of rejections observed in the Inequity and Food Control conditions (.45 and .48, respectively) because at least half of the data in these conditions came from subjects that had already participated as Monkey A and because there were no grounds for social comparison in the later condition. The same argument applies to the significantly higher rejections in the Food Control than in the Equity condition (.05).

Finally, according to the third hypothesis, the mere presence of the preferred food within sight of Monkey A induced more rejections of the less-preferred food in the Inequity, Effort Control, and Food Control conditions (.45, .80 and .48, respectively) compared to the Equity condition (.05). In this hypothesis, displaying the preferred food in the experimental setting established an expectation that this was the food to receive. The expectation was then violated by the less-preferred food offered in exchange for the token. Evidence that the presence of a higher-value reinforcer decreases the effectiveness of a lower-value reinforcer was provided by Dubreuil et al. (2006) and Fontenot et al. (2007), for example.

Subsequent studies tried to disentangle the inequity-aversion and the frustration hypotheses. Roma et al. (2006), for example, investigated whether inequity aversion or frustration induced the rejections of the less-preferred food in capuchin monkeys. Throughout the experiment, each monkey in a pair played a single role, either as Monkey A or as Monkey B, and the animals received food "for free" without having to perform any particular task. In the Inequity condition, Monkey A received cucumber slices and Monkey B received grape slices; in the Equity condition, both monkeys received cucumbers. Inequity aversion was assessed in the A monkeys during the Inequity condition and frustration was assessed in the B monkeys during the Equity condition. The results suggested that frustration was the main cause of the rejections, both because the B monkeys rejected significantly more than the A monkeys, and because the A monkeys' proportion of rejections approximated that observed in the Equity condition of Brosnan and de Waal's (2003) original study. (Brosnan and de Waal (2006) later reanalyzed their original data set [Brosnan & de Waal, 2003] to assess whether it could be accounted for by frustration, but they not find a significant effect.)

Because of procedural differences, relating the processes that led to rejections in these different experiments is not straightforward (Brosnan & de Waal, 2006; Talbot et al., 2017). There is some evidence that the appetitive value of an edible stimulus varies depending on whether it is contingent on a required response or offered "for free" (Dindo & de Waal, 2007), and also some evidence that effort and food quality interact in rejections of the type reported in the inequity-aversion literature (Sheskin, Ashayeri, Skerry, & Santos, 2014; van Wolkleten et al., 2007). Considering the impact that the task might have on the phenomenon of interest, Silberberg et al. (2009) replicated the general experimental design of Roma et al.'s (2006) study with capuchin monkeys exchanging tokens for pine nuts, the preferred food, and sunflower seeds, the less-preferred food. Once again, inequity aversion was assessed in monkeys A and frustration in monkeys B. What is surprising is that neither hypothesis was confirmed, because regardless of their role (A or B), the monkeys virtually never refused the less-preferred food.

Whether rejection of the less-preferred food stems from inequity aversion or from frustration is therefore still open to debate. Other possible explanations have not been ruled out either. In this article, we approach the frustration hypothesis by focusing on the objective operation that induces frustration—changing the food exchanged for the token from a preferred to a less-preferred one—rather than on emotional byproducts. It has been well-documented since the beginning of the 20th century that this type of operation affects performance on a task that an animal previously mastered (e.g., Crespi, 1942; Flaherty, 1982; Flaherty and Largen, 1975; Mackintosh, 1974; Mackintosh, Little, & Lord, 1972). Consider Elliot's (1928, Experimental Group B) seminal work: rats initially learned to run a 14-choice-points maze to encounter bran mash in a goal box. After only nine trials, the rats made no more than 1.4 errors on average. Next, sunflower seeds were substituted for the bran mash in trials 10 to 15, and the average number of errors increased to 4.2. When the bran mash was reintroduced from trial 16 onwards, the number of errors immediately returned to baseline level. The decrease in performance that followed changing the type of food reinforcer was later called *successive negative contrast* (Mackintosh, 1974; Reynolds, 1961).

Here we hypothesize that the monkeys rejecting tokens and/or the less-preferred food is an instance of negative contrast, and we test this hypothesis experimentally. If the contrast between the types of food that a subject receives across conditions induces rejections, we should observe a decrease in the number of exchanges for the less-preferred food after a brief period of exchanging tokens for the preferred food. Rejections should occur both under the usual protocol (wherein the monkeys work in pairs) and under a new protocol wherein each monkey works alone and is not exposed to social factors such as the presence and behavior of a conspecific.

Method

Subjects

Nine male capuchin monkeys (*Sapajus sp.*; age range: 8–26 years old) with extensive experience on equivalence-class formation and color discrimination tasks participated. The monkeys were residents of the Primate Experimental School of the Federal University of Pará and lived in groups of three to four in indoors–outdoors cages where they had free access to water. They were fed with a vegetable, fruit, and chow diet three times a day and were not under any food-deprivation schedule, but worked in the experimental sessions before their first daily meal (at 7 A.M.).

Materials, Apparatuses, and Experimental Setting

The animals worked in two adjacent experimental chambers (58-cm high x 59.9-cm long x 59.9-cm deep each) made of translucid-acrylic walls and aluminum frames. The chambers were housed in a dedicated experimental room equipped with artificial light, air conditioning, and speakers that continuously played classical music to mask extraneous noise. On the center of the front wall of each chamber, a 30-cm high x 23-cm long window with metal bars separated by 4 cm allowed the monkeys to reach out for the tokens and the food pieces, which were placed on an acrylic platform mounted on the bottom frame of the windows.

The preferred food consisted in halves of grapes.[1] The less-preferred food consisted in quarters of cucumber slices, cut to approximate the volume of half a grape. From now on, we refer to these food pieces simply as grape and cucumber, respectively. Grapes and cucumbers were part of the animals' diet and were selected based on systematic observations of their preference. The tokens were 20-mm, brown PVC caps (Tigre®).

The experimenter had her face covered with an opaque surgical mask and stood on her feet approximately 45-cm from the front wall of the chambers. An opaque curtain behind the experimenter hid the food items that would be used later in the session or the trial. The experimenter's assistant controlled trial arrangement and the experimental events from behind the curtain.

Procedure

The experiment comprised three phases. In the first phase, a simple-preference test confirmed that grapes were preferred to cucumbers. In the second phase, the animals learned to exchange tokens for cucumbers. The third and final phase tested for successive negative contrast along three conditions that differed with respect to the type of food offered in exchange for the tokens. Before the final phase started, the subjects were assigned to one of three groups whose members were matched as closely as possible on age and dominance. Two of the monkeys in a group simultaneously underwent the sessions on the adjacent experimental chambers, whilst the other monkey of the group worked alone—that is, without a partner in the adjacent chamber. All the animals underwent the first and second phases alone. We next describe the phases in detail.

Simple-preference test In a single 16-trial session, each monkey was given a choice between grape and cucumber. At the beginning of each trial, the experimenter extended both arms backward and toward the assistant through an opening in the curtain; the assistant then placed a grape in one of the experimenter's hands and a cucumber in the other. Next, the experimenter placed both of her hands (palms upward, approximately 20-cm apart) about 12-cm from the chamber window. Once the monkey picked one of the food items, the experimenter withdrew the other hand (the one with the item not chosen), in the direction of the assistant, who removed the rejected item. On the few trials when an animal picked both items, the trial was repeated and only the second trial presentation was considered. The intertrial interval was the time that the monkey took to eat the chosen food, plus the time the assistant took to place the items of the next trial in the hands of the experimenter. The position of the grapes and cucumbers on the experimenter's left and right hands was pseudorandomized, with the restriction that each food type appeared an equal number of trials on both sides and no more than three trials in a row on the same side.

Shaping of token exchange Across 25-trial sessions, each monkey was shaped to exchange tokens for cucumbers. At the beginning of each trial, the assistant placed a token in the experimenter's right hand and a cucumber in the experimenter's left hand. Next, the experimenter extended her right hand towards the chamber, placed the token on the window platform, and offered her upward palm at approximately 12-cm from the window. When the monkey picked up the token and gave it back to the experimenter, she extended her left arm towards the chamber and offered the cucumber, visible on her left palm. The monkey could then collect and eat the cucumber. Shaping lasted 12–14 sessions and until the monkey completed the full exchange chain on at least 80% of the trials of a session.

Token exchange task Once all the monkeys learned to exchange tokens, the third, critical phase of the experiment began. This phase, inspired by the logic of a multiple-baseline design, involved three serial conditions introduced at different moments in different groups of monkeys. In the first and third conditions of this phase, tokens were exchanged for cucumbers; in the second condition,

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[1] At first, the grapes had their seeds on, but once we noticed that one of the monkeys (Tico) took off the seeds before eating, we started removing all the seeds from the grapes before running the experimental sessions.

tokens were exchanged for grapes. With our design we aimed at comparing cucumber rejections across the first and third conditions (that is, before vs. after the introduction of the second condition) while controlling for possible confounding variables by varying the duration of the first condition across groups of monkeys. Group 1 had six sessions in the first and second conditions and 18 sessions in the third condition; Group 2 had 12 sessions in the first condition, 6 in the second and 12 in the last condition; finally, Group 3 had 18 sessions in the first condition and 6 sessions in the second and third conditions. Figure 1 illustrates the experimental design.

Each session in a given condition had 25 trials for the monkeys that worked alone and 50 trials that alternated between monkeys for the monkeys that worked in pairs. In the first session of the second and third conditions (henceforth called *transition sessions*), the first five trials presented to a monkey had the food of the preceding condition exchanged for the tokens, whereas the next 20 trials had the food item programmed for this condition exchanged for the tokens. This was done to ensure that eventual performance disruptions at the beginning of a condition were due to changes in the type of food reinforcement, as opposed to nonspecific factors such as warm-up. The remainder of the sessions in a condition only had the food programmed for this condition (cucumbers in the first and third conditions, grapes in the second condition) exchanged for the tokens.

Token and food presentations were as in the shaping phase, with additional temporal constraints: A monkey had up to 60 s to return the token to the experimenter once the token was placed on the platform, and up to 10 s to eat the food once the experimenter offered it. Exchanges that respected these temporal constraints were registered as acceptance of the food. Not giving the token back within 60 s, discarding the token or the food (e.g., by throwing them away), or not eating the food item within 10 s were considered rejections. All other parameters and experimental events were as in the preceding phase.

Results

Halfway through the first condition, subject Raul started being reluctant to enter the experimental chamber and missed several sessions; in addition, on the sessions in which he participated from this point on, cucumber acceptances varied largely across trials and did not stabilize. We were unable to identify what caused these changes in Raul's behavior. Because he was the partner of monkey Negão, we kept Raul in the experiment, in accordance with our experimental design, but we discarded his data altogether because of a probable lack of internal validity.

Simple-Preference Test

All subjects chose the grapes more frequently than the cucumbers on the simple-preference trials (grape choice proportion for Euzébio, Tico, Abu, Negão, Newson, Tadinho, Michael: 1.00; ET: .82; all *p*'s < .05, two-tailed binomial test). This result confirms that grapes are preferred to cucumbers and corroborate their use as preferred and less-preferred foods, respectively.

Token Exchange Task

Figure 2 presents the acceptance proportion per session for each monkey (see Table 1 in the Appendix for individual monkey rejection proportions across sessions). There were a few instances of monkeys that did not run all the sessions programmed for a condition for one reason or another, such as a veterinarian prescription, for example. These missing sessions did not impair data analysis, however, because the procedure still provided serial measures within each condition and because data in a condition were stable before moving on to a new condition (which is one of advantages of a procedure inspired by multiple-baseline designs).

Both cucumbers and grapes sustained high and stable proportions of token exchanges in the first and second conditions, respectively. In the few cases when acceptance declined, the decline did not persist across sessions (e.g., Abu's 10th session and Tadinho's 14th session—we could not identify what caused these decreases). Rejections in both the first and second conditions were mainly due to accidental fall of the tokens.

The one exception to this overall pattern was Tico's decline in the acceptance of the grape on the last sessions of the second condition. This was the monkey who started to remove the seeds from the grapes—perhaps rejections in this condition were related to the added cost to consume the grapes. In any case, because Tico was a member of a pair and we did not want to modify the experimental design for his partner, we chose to move on to the third condition despite Tico's data lacking stability.

A visual inspection of Fig. 2 suggests that acceptance proportions decreased—or equivalently, that the rejection proportions increased—when cucumbers were reintroduced in the third condition. Three different patterns of results can be discerned in Fig. 2: an immediate drop in acceptance during the first session of the third condition (e.g., ET, Newson and Tadinho); a delayed drop after two or three sessions in the condition (e.g., Tico and Negão); and no changes in acceptance (e.g., Euzébio, Abu, and Michael). When present, lower acceptance proportions persisted for at least two sessions before recuperating. Finally, rejections in the third condition were mainly cases of the monkeys not eating the cucumbers at all.

A *t*-test for independent samples with the difference of rejection proportions between the first and the third conditions showed no significant group effect between monkeys that participated in pairs (M_{diff} = .05, *range*: .00 – .09) and monkeys that participated alone [M_{diff} = .07, *range*: -.09 – .18; $t(6) = .44$, $p = .67$]; as a result, the data of the eight subjects were pooled together. A *t*-test for matched samples confirmed that the mean proportion of rejections in the first five sessions of the third condition (M_{rej} = .10, *range*: .00–.21) was significantly greater than the mean proportion of

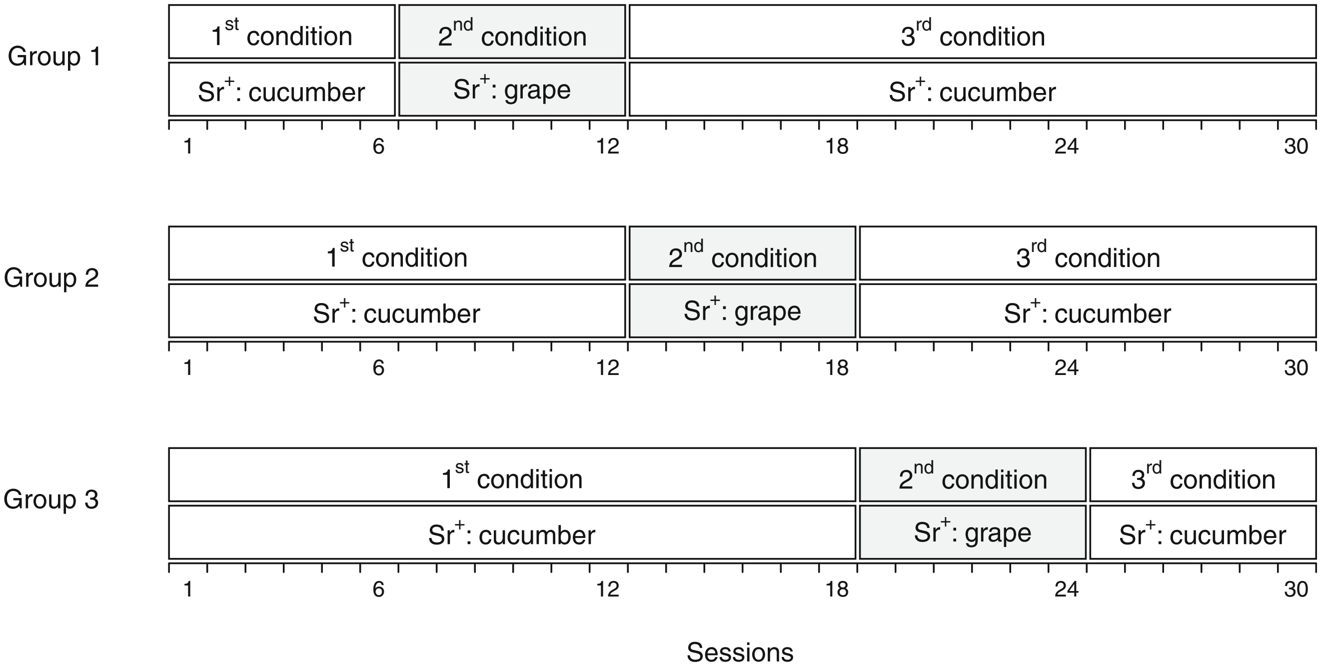

Fig. 1 Schematics of the experimental design

rejections in the last five sessions of the first condition (M_{rej} = .04, *range*: .00 – .11; *t*(7) = 1.95, *p* = .05, Cohen's *d* = .69; we conducted a one-tailed test because the proportions of rejections were markedly low and stable in the first condition and therefore could not decrease any further). Visual inspection of Fig. 2 also suggests that the acceptance proportions varied more in the third condition. Taking the standard deviation as a descriptive measure of variability, however, did not reveal any significant difference between the third (M_{stdDev} = .10, *range*: .00 – .24) and the first conditions (M_{stdDev} = .05, *range*: .00 – .20; *t*(7) = 1.28, *p* = .24).

To further evaluate the impact of changing the type of food exchanged for the tokens, Figs. 3 and 4 present trial-by-trial acceptances in the transition sessions—the first session of the second and third conditions, respectively. There was no

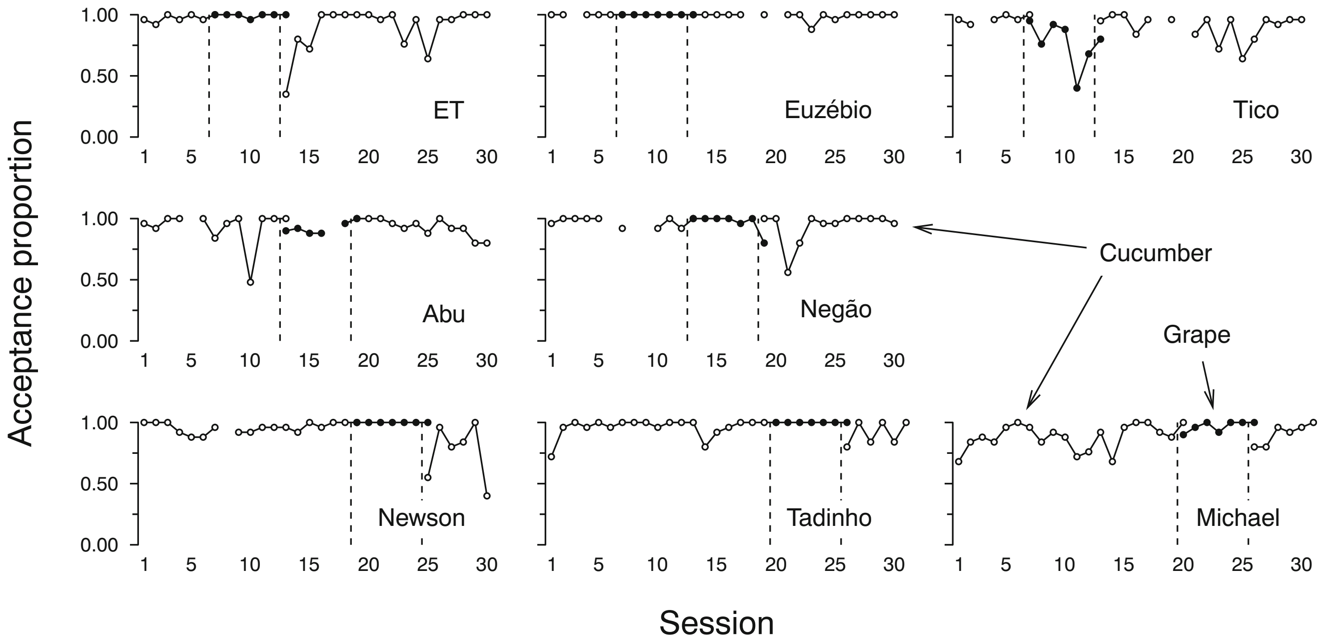

Fig. 2 Individual acceptance proportion per session throughout the three conditions of the token exchange task. Dashed lines separate the conditions. In each row, the leftmost panel shows the data of the monkey that worked alone in a group and the two rightmost panels show the data of the subjects who worked as a pair in the group

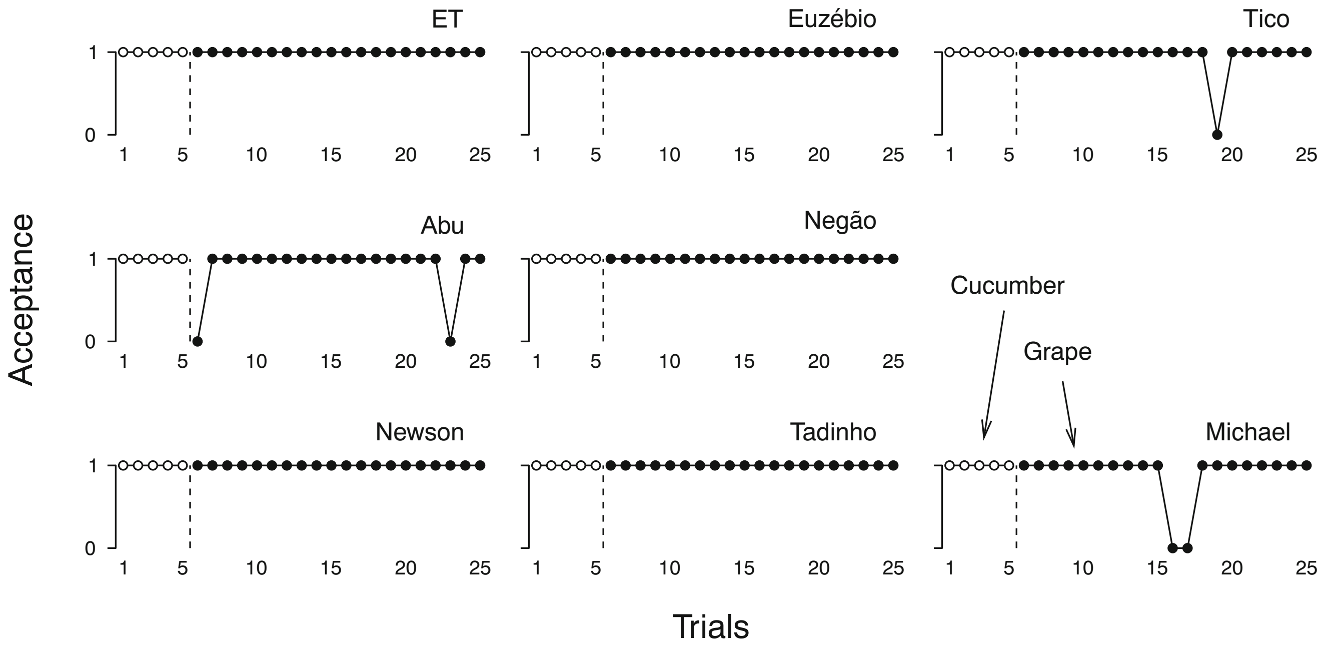

Fig. 3 Individual trial-by-trial performance in the cucumber ➔ grape transition session. On the y axis, 0 stands for rejection and 1 for acceptance. The vertical dashed line separates the first five trials of the session from the last 20 trials. In each row, the leftmost panel shows the data of the monkey that worked alone in a group and the two rightmost panels show the data of the subjects who worked as a pair in the group

increase in rejections in the transition between the first and second conditions (cucumber ➔ grape).

The second transition (grape ➔ cucumber) globally induced more rejections, however. Because a higher number of rejections only occurred when the cucumber was reintroduced and not after both transitions, the lower acceptance can only be assigned to reestablishing the less-preferred food as a reinforcer for the token-exchange task, and not to simply changing the type of food reinforcement across conditions. This aspect of the data also shows that control of the token-exchange response by the cucumber only decreased when it was reintroduced after, and not before, experience with the preferred food.

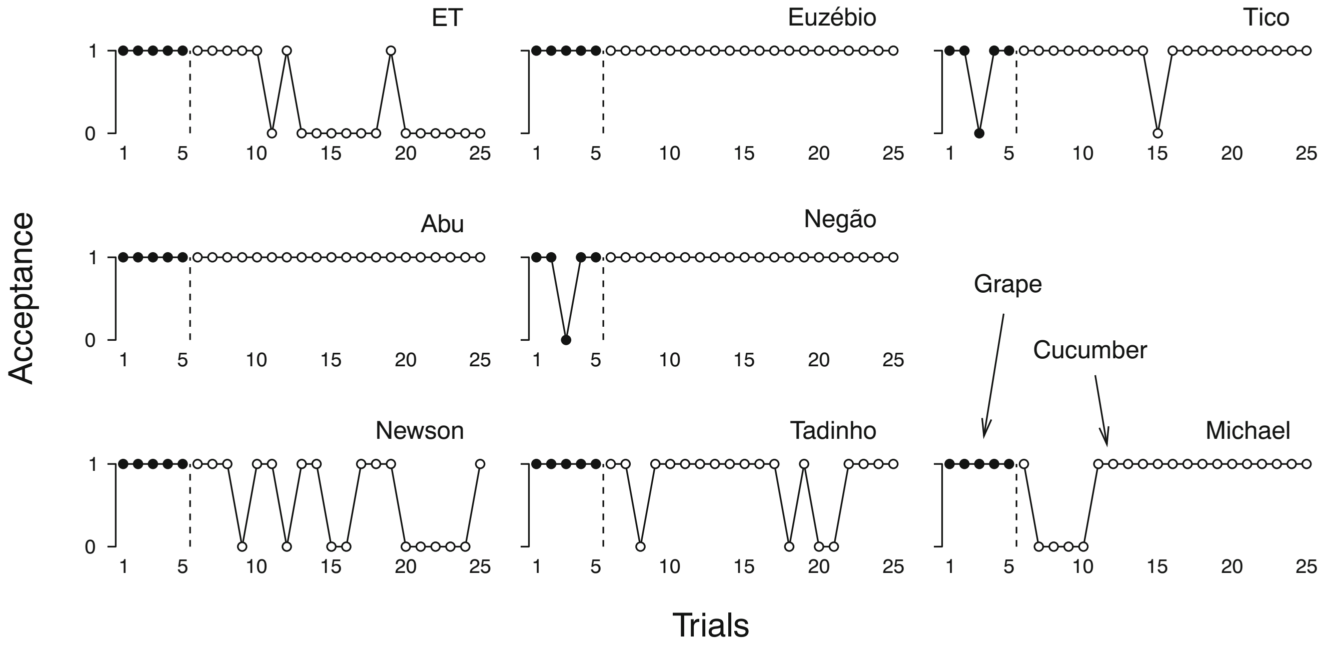

Fig. 4 Individual trial-by-trial performance in the grape ➔ cucumber transition session. On the y axis, 0 stands for rejection and 1 for acceptance. The vertical dashed line separates the first five trials of the session from the last 20 trials. In each row, the leftmost panel shows the data of the monkey that worked alone in a group and the two rightmost panels show the data of the subjects who worked as a pair in the group

Discussion

We hypothesized that capuchin monkeys' rejections of a less-preferred food in a token-exchange task was a case of successive negative contrast rather than a reaction to social inequity. We predicted that the less-preferred food would initially sustain token exchanges, but its reinforcing function would later decrease following experience with a preferred food in the same task. Furthermore, rejections should not depend primarily on a social-comparison process, and as such would occur in monkeys that worked along with a conspecific as well as in monkeys that were not exposed to a partner. Regardless of our hypothesis, contrasting the level of rejection between subjects that worked in pairs and subjects that worked alone should reveal whether rejections based on negative contrast are socially boosted.

As predicted, exchanges decreased when the less preferred food was reintroduced, revealing three types of decrease: steep and immediate (monkeys ET and Newson), weak and immediate (Tadinho), and steep and delayed (Negão and Tico). To our knowledge, this is novel evidence of successive negative contrast in capuchin monkeys, evidence obtained in a procedure that properly controls for competing factors such as unequal reinforcement between subjects and having the preferred food within the subjects' sight. Aside from this, we found no evidence that the rejections were socially enhanced. They were neither more pronounced nor more persistent in the subjects that worked in pairs than in the subjects that worked alone. Neither did we observe social interactions such as vocalizations and gazing, which would have indicated that the monkeys were reacting to their partner's responses on a given trial.

Negative contrast may therefore be involved in the rejections documented in the inequity-aversion studies that varied food type across conditions—as was the case in Brosnan and de Wall's (2003) study, for example. In particular, the second transition in our study (grape ➔ cucumber) seems comparable to the transition from equity to inequity that provided some of the data attributed to inequity aversion by Brosnan and de Waal. Also, the highest individual proportions of rejections in our study were comparable to the mean proportion of rejections in Brosnan and de Waal's study: ET: .65, Newson: .45, Negão: .44, and Tico: .36 in our experiment; .45 on average in theirs. Similar levels of rejection were not observed in our first condition, when the less-preferred food had not been preceded by the preferred food. We can therefore attribute the observed rejections to the one variable we manipulated. The same cannot be said of previous studies that had the preferred food within sight while manipulating frustration or reinforcement inequality (e.g., Brosnan & de Waal, 2003; Fletcher, 2008; Fontenot et al., 2007; Silberberg et al., 2009).

This being said, the group-average rejection proportion in our study was smaller than in Brosnan and de Waal's. Perhaps negative contrast contributes to rejections in their type of task, but in interaction with other factors—we speculate that having the preferred food within sight might be the most important. Though rejections were not as pronounced as we expected, however, they were greater in our study than in other studies that investigated frustration (e.g., Silberberg et al., 2009), and the effect size we obtained was moderate, as measured by Cohen's *d*. It is not clear why Silberberg et al. observed virtually no rejection. These authors suggested that their using pine nuts and sunflower seeds as food items might have interfered with the results. As an alternative, it could be that the size of the food items, rather than their type, is a critical aspect across studies, for nuts and seeds are considerably smaller than grape and cucumber slices. Further empirical tests could address this issue.

An interesting feature of our data was that cucumber rejections were transient and did not persist with continued exposure to the third condition. Observing that rejections decreased or ceased over time was only possible because our design continuously measured rejections/acceptances under each condition. There are no reports in the inequity-aversion literature of rejections of the less preferred food that decreased or ceased over time, because these studies did not implement more than two sessions with the less preferred food (Dubreuil et al., 2006; Roma et al., 2006; Silberberg et al., 2009, Talbot et al., 2017; van Wolketen et al., 2007). The transient nature of the rejections in our study strengthens our hypothesis that they stem from negative contrast because other species, including pigeons working in a free-operant procedure, also show transient negative contrast effects (e.g., Nevin & Shettleworth, 1966). The short temporal span of negative contrast might be tied to memory-related processes: if the memory trace of receiving grapes in exchange for the tokens decays throughout the third condition, or if there is a generalization decrement, it is expected that negative contrast, as revealed by the rejections, should also decay (Capaldi, 1967; van Wolkenten et al., 2007).

Although the present results are consistent with our hypothesis, they have their limitations. Even though we expected differences of contrast magnitude among subjects, we did not anticipate that it could take from two to three sessions to observe the effect of reintroducing the less-preferred food, as was the case with some monkeys. Neither did we expect late rejections (e.g., sessions 11 and 13 for ET and session 9 for Euzébio) or alternations between greater and lower rejection proportions (e.g., Newson, Tadinho, and Abu). These patterns might be speculatively assigned to residual effects of our manipulation, pointing to a longer-range form of negative contrast, but in the absence of stronger evidence the issue is better left to follow-up studies. Also, even though the logic of multiple-baseline designs does not call for a large sample size, having to disregard the data from one of our subjects limits our conclusions.

Because the present study is, to our knowledge, the first to document successive negative contrast in capuchin monkeys, the obligatory next step should be to replicate our findings. Silberberg et al. (2009) have pointed out that the effects observed in this research area tend to be labile, which makes the case for systematic replication even stronger. For example, to evaluate the possibility that maintaining the preferred food within sight might interact with negative contrast, a further step would be to implement a modified version of our procedure that varies the visibility of the preferred food across conditions. Such a modified procedure would allow one to evaluate the role of food visibility in inequity-aversion studies, and therefore to further the experimental analysis of these interesting phenomena.

Acknowledgements We thank Edilson Pastana, Anna Carolina Damasceno and the members of the Primate Experimental School for their cooperation. APR and ST conducted the experiment under the supervision of MPC and were supported by master's studentships from the National Council for Scientific and Technological Development (CNPq) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), respectively.

Availability of Data and Materials The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding The first author was supported by a master's studentship from the National Council for Scientific and Technological Development (CNPq) and the third author by a master's studentship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). The authors declare that they have no other conflicts of interest.

Compliance with Ethical Standards

All applicable national and institutional guidelines for the care and use of animals were followed. The procedures performed in this study with capuchin monkeys (*Sapajus sp.*) were in accordance with the ethical standards of the Primate Experimental School and the Animal Ethics Committee of the Federal University of Pará, Brazil (CEPAE 040-2015).

Appendix

Table 1 Individual rejection proportions throughout the token exchange task. The gray areas stand for the cucumber conditions and the white areas stand for the grape condition

Session	ET	Euzébio	Tico	Abu	Negão	Newson	Tadinho	Michael
1	0.04	0.00	0.04	0.04	0.04	0.00	0.28	0.32
2	0.08	0.00	0.08	0.08	0.00	0.00	0.04	0.16
3	0.00	---	---	0.00	0.00	0.00	0.00	0.12
4	0.04	0.00	0.04	0.00	0.00	0.08	0.04	0.16
5	0.00	0.00	0.00	---	0.00	0.12	0.00	0.04
6	0.04	0.00	0.04	0.00	---	0.12	0.04	0.00
7	0.00	0.00	0.05	0.16	0.08	0.04	0.00	0.04
8	0.00	0.00	0.24	0.04	---	---	0.00	0.16
9	0.00	0.00	0.08	0.00	---	0.08	0.00	0.08
10	0.04	0.00	0.12	0.52	0.08	0.08	0.04	0.12
11	0.00	0.00	0.60	0.00	0.00	0.04	0.00	0.28
12	0.00	0.00	0.32	0.00	0.08	0.04	0.00	0.24
13	0.65	0.00	0.05	0.10	0.00	0.04	0.00	0.08
14	0.20	0.00	0.00	0.08	0.00	0.08	0.20	0.32
15	0.28	0.00	0.00	0.12	0.00	0.00	0.08	0.04
16	0.00	0.00	0.16	0.12	0.00	0.04	0.04	0.00
17	0.00	0.00	0.04	1.00	0.04	0.00	0.00	0.00
18	0.00	---	---	0.04	0.00	0.00	0.00	0.08
19	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.12
20	0.00	---	---	0.00	0.00	0.00	0.00	0.10
21	0.04	0.00	0.16	0.00	0.44	0.00	0.00	0.04
22	0.00	0.00	0.04	0.04	0.20	0.00	0.00	0.00
23	0.24	0.12	0.28	0.08	0.00	0.00	0.00	0.08
24	0.04	0.00	0.04	0.04	0.04	0.00	0.00	0.00
25	0.36	0.04	0.36	0.12	0.04	0.45	0.00	0.00
26	0.04	0.00	0.20	0.00	0.00	0.04	0.20	0.20
27	0.04	0.00	0.04	0.08	0.00	0.20	0.00	0.20
28	0.00	0.00	0.08	0.08	0.00	0.16	0.16	0.04
29	0.00	0.00	0.04	0.20	0.00	0.00	0.00	0.08
30	0.00	0.00	0.04	0.20	0.04	0.60	0.16	0.04
31	---	---	---	---	---	---	0.00	0.00

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