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Language-Trained Chimpanzees (*Pan troglodytes*) Delay Gratification by Choosing Token Exchange Over Immediate Reward Consumption

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Abstract

Token exchange inherently introduces an element of delay between behavior and reward and so token studies may help us better understand delay of gratification and self-control. To examine this possibility, we presented three language-trained chimpanzees with repeated choices involving different foods that could be eaten immediately or lexigram (graphic symbol) tokens that represented (and could be traded for) foods later. When both options were foods, chimpanzees always chose more preferred foods over less preferred foods. When both options were lexigram tokens representing those same foods, performance remained the same as chimpanzees selected the higher value token and then traded it for food. Then, when faced with choosing a token that could be traded later or choosing a food item that could be eaten immediately, most chimpanzees learned to make whatever response led to the more preferred food. They did this even when that meant selecting a high value lexigram token that could be traded only two to three minutes later instead of a medium value, but immediately available, food item. Thus, chimpanzees flexibly selected tokens even though such selections necessarily delayed gratification and required forgoing immediately available food. This finding illustrates the utility of symbolic token exchange for assessing self-control in nonhuman animals.

Keywords

chimpanzees; *Pan troglodytes*; self-control; delay of gratification; symbols; tokens

1. Introduction

Self-control plays an important role in many behaviors, by allowing organisms to overcome immediate interests for the sake of pursuing better long-term outcomes. However, immediate gratification is often favored by biological and psychological factors [Stephens et al., 2004; Kalenscher et al., 2006], and in some situations it can be advantageous to act in support of short-term interests, such as when resources are physically or temporally scarce. Therefore, organisms often are faced with this conflict of immediacy (or impulsivity) versus overall value (or self-control), and there is variability both within and between species with regard to how this conflict plays out.

One way in which humans can be aided in choosing self-control over impulsivity is by substituting symbolic representations for actual rewards. For example, Mischel and Moore [1973] reported that the use of symbols to represent foods improved children's performance

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in the delay of gratification paradigm. In this paradigm, children are shown two reward options and told that if they wait until an experimenter returns, they can have the more preferred reward, but if they can't wait any longer, they can call upon an experimenter to return with the less preferred reward. Mischel and Moore found that children delayed calling upon the experimenter for a longer period of time when they viewed symbolic representations of the reward items (or similar items) during the delay period than when actual rewards (or nothing at all) were visible during the delay. Images corresponding to the preferred reward produced the greatest delays in calling the experimenter back and this suggested that the symbols may have functioned as a reminder of the reward without provoking the frustration that results from having the reward present and trying not to eat it. Chimpanzees also have been tested in this paradigm and showed some success with delaying gratification when both reward options were represented by visible foods, photographs representing the foods, and lexigram symbols representing the foods, although performance was not consistently different across such conditions [Beran et al., 1999].

There are also reports of symbols facilitating self-control performance in nonhuman animals (hereafter animals), particularly within the reversed-reward contingency task. In this paradigm, an individual must learn to select the lesser of two food quantities in order to receive the greater. This is extremely difficult for animals to do, as they show strong biases to continue to point to the larger amount of food even though that means they will not receive it. However, Boysen and colleagues found that replacing both food options with laminated Arabic numerals allowed chimpanzees (*Pan troglodytes*) to overcome the urge to point directly to the preferred option and instead make the optimal response to the lesser option [Boysen & Berntson, 1995; Boysen, Bernston, Hannan, & Cacioppo, 1996]. This finding has since been replicated in capuchin monkeys by replacing food items with three-dimensional tokens in the reversed-reward task [*Cebus apella*; Addessi & Rossi, 2011].

Another method that has potential for examining self-control in animals is token exchange. Token exchange is the act of trading an object for a reward or resource of some kind, and this research method has been used to study a variety of behavioral phenomena in nonhuman primates [e.g., Wolfe, 1936; Cowles, 1937; Westergaard, Liv, Chavanne, & Suomi, 1998; Addessi, Crescimbene, & Visalberghi, 2007; Brosnan & de Waal, 2004; Lakshminarayanan, Chen, & Santos, 2008; Pelé, Dufour, Thierry, & Call, 2009]. What makes this behavior particularly useful for the study of self-control is that tokens inherently introduce an element of delay into a test situation because the participant must take the time to exchange the token in order for a reward to be obtained. Delayed reward is a hallmark of many self-control tasks and situations, and when it is combined differentially with discrete choice options, a self-control paradigm can be constructed.

Despite the potential utility of token exchange for the study of self-control, it is seldom integrated into this line of research [but see Hackenberg, 2009, for a review of research involving tokens in related choice and reinforcement paradigms]. In two related studies, pigeons (*Columbia livia*) were tested in a token exchange version of a common self-control task involving multiple discrete choices between a small reward available after a short delay and a larger reward available after a longer delay [Jackson & Hackenberg, 1996; Hackenberg & Vaidya, 2003]. In those studies, pigeons' selection of the smaller-sooner option resulted in the availability of one token (lighting of a single LED lamp), whereas selection of the larger-later option resulted in the sequential presentation of three tokens (LED lamps). Pigeons could then exchange (peck) each acquired token for brief access to grain. The experimenters varied the delay to token presentation as well as the delay to the exchange opportunity and found that pigeons' choices operated primarily to minimize the delay to food reward and secondarily to maximize the reward amount. In another example, Sousa and Matsuzawa [2001] presented a chimpanzee with a computerized task in which it

could earn digital tokens by completing trials in a computerized task. These tokens could be "exchanged" at different times for individual food rewards. The experimenters found that the chimpanzee would accumulate multiple tokens before deciding to exchange. In doing so, this chimpanzee delayed gratification until the exchange point. These few studies show that token exchange can be a valuable tool for comparative research in this area [also see Pelé, Dufour, Micheletta, & Thierry, & 2010 for an example of an exchange paradigm not involving tokens].

In the present study, we examined self-control behavior in chimpanzees by presenting them with choices between different types of foods and exchangeable tokens. Early work in the area of token reinforcement has shown that chimpanzees are willing to work for individual tokens exchangeable for rewards [Wolfe, 1936], and that they are willing to do so for multiple trials until an exchange opportunity is made available [Cowles, 1937], and so this species is well suited for assessments of self-control involving token exchange. Building upon those earlier studies, we assessed whether chimpanzees could flexibly integrate symbols into a choice task in which self-control was required to maximize outcomes in terms of obtaining more preferred, but delayed, food rewards. One novel aspect of this research is that these are meaningful symbols that have been established as representing specific food items for these chimpanzees. These chimpanzees were raised from an early age in an environment in which they learned to use lexigram symbols on a keyboard and respond to the lexigram use of others [see Rumbaugh and Washburn 2003]. We took advantage of their knowledge of these symbols in the present experiment and transferred the lexigrams from the keyboard to tokens that could be manipulated and exchanged at specific future times for the food items that they represented. By doing this, we were able to test whether chimpanzees could inhibit selecting immediately consumable food items in favor of selecting symbols that represented more preferred food items that could be consumed at a later time. Although previous studies have integrated tokens or symbols into self-control and delay of gratification tests, none have directly pitted these response options against physically present food rewards in order to examine self-control processes.

2. Methods

2.1. Participants

We tested three chimpanzees - Lana (female, age 39), Panzee (female, age 23), and Sherman (male, age 36), all housed at the Language Research Center of Georgia State University. All chimpanzees had continuous access to water and were fed a balanced diet of fruit, vegetables, and protein sources each day independent of their performance in this experiment. All were highly experienced in a variety of different cognitive tests including many experiments involving judgments between visible and nonvisible sets of food items [e.g., Beran 2001; Beran & Beran 2004] and experiments involving delay of gratification [e.g., Beran et al. 1999; Beran 2002; Evans & Beran 2007]. The chimpanzees had also participated in multiple previous studies involving token exchange [Brosnan & Beran, 2009; Evans, Beran, & Addessi, 2010; Beran, Evans, & Hoyle, 2011; Evans, Beran, Paglieri, & Addessi, in press].

All chimpanzees were reared in environments in which they learned to associate arbitrary geometric icons called lexigrams with various foods, items, places, actions, and individuals [Rumbaugh, 1977; Savage-Rumbaugh, 1986; Rumbaugh & Washburn, 2003]. These lexigrams operate symbolically for the chimpanzees, allowing them to use symbols to make requests and otherwise perform tasks in which they have to represent items that are not physically present. Previous research has indicated that these chimpanzees can use lexigrams to inform themselves about immediately available or delayed rewards, and then choose the delayed reward when it is of a higher value than the immediate reward [Beran et

al., 1999]. However, the chimpanzees had never had to forgo actual foods to instead collect lexigrams that they could only trade later for better foods.

2.2. Apparatus

We used clear plastic bowls (approximately 15 cm in diameter) to present foods and tokens to the chimpanzees. We positioned a pair of these bowls at opposite ends of a black wooden bench (48 cm high, 67 cm wide, and 36 cm deep). The bench had a sliding top shelf that allowed both choice options to be moved toward a chimpanzee at the same time. The tokens consisted of laminated lexigram symbols embossed on ½ cm × 5 cm × 5 cm pieces of plastic. All three chimpanzees had learned to use similar lexigram tokens in a prior study involving exchange between conspecifics [Brosnan & Beran, 2009]. The lexigrams used for this experiment represented apple, banana, bread, and *M&Ms* candy. These four lexigrams were chosen because all chimpanzees consistently used them to name the foods they represented and because all chimpanzees showed a clear preference for *M&Ms* and banana over bread and apple. Individual lexigram tokens earned the chimpanzees 1 *M&Ms* candy, ⅛ of a banana, ¼ of a slice of bread, or ⅛ of an apple. Each chimpanzee was given a large (30 cm) bowl in which they could place any acquired tokens prior to exchange.

2.3. Procedure

Each chimpanzee was tested individually in a separate cage. Chimpanzees were tested between 1000 hr and 1300 hr on a given test day for several days each week. Each session began with an experimenter (E1) sitting opposite the test apparatus from the chimpanzee. In each trial, E1 placed two choice options on opposite ends of the sliding shelf and then slid the options towards the chimpanzee. The choice options always consisted of one high preference item (*M&Ms* or banana) and one medium preference item (bread or apple). E1 immediately handed the chimpanzee whichever item it selected. If the item was a food, then the chimpanzee could immediately eat it. If the item was a token representing a food, the chimpanzee could carry the token to a second experimenter (E2) later and exchange it for the food item it represented. E2 always held a bowl containing all four food types and his location varied according to the experimental phase (see below).

In Phase 1, each chimpanzee completed 16 trials in a session. In trials 1–4 of this phase, E1 presented choice options that were all actual food items (and chimpanzees could immediately consume any selected food item following a trial). Each combination of high preference and low preference food types was presented once in a random order within this trial block. In trials 5–8, E1 only presented choice options that were lexigram tokens representing food items, and E2 (holding the container of food items) was always located 3–5 m from the chimpanzee. Therefore, after each of these trials, the chimpanzee could immediately take any selected lexigram token to E2 and exchange it for the food item it represented, and this took approximately 10–15 s to accomplish. Each combination of high preference and low preference tokens was presented once in a random order within this trial block. In trials 9–16, E1 presented the choice between a food item and a lexigram token. Each of the four food items (listed above) was presented twice as an actual food and twice as a lexigram token representing food. Each possible combination of one high preference token (banana or *M&Ms*) and one low preference food item (bread or apple) was presented once, and each possible combination of one high preference food (banana or *M&Ms*) and one low preference token (bread or apple) was presented once within these 8 trials, in a random order. As in the previous trials, if the chimpanzee selected an actual food it could eat that food immediately, and if the chimpanzees selected the lexigram token it could immediately carry it to E2 and exchange it to receive the food item that it represented. Each chimpanzee completed three sessions in this phase.

In Phase 2, each chimpanzee completed two blocks of 15 trials in a session. In each of these trials, E1 again presented the chimpanzee with a choice between a real food item and a lexigram token (as in Trials 9–16 within sessions of Phase 1). However, these trials were different than those of Phase 1 in that the token was always of the more preferred food type (banana or *M&Ms*) whereas the food item was always of the less preferred type (bread or apple). These trials also differed from Phase 1 trials in that E2 (and the bin containing the four food types) remained out of view of the test area in this phase. Only at the end of each 15-trial block did E2 enter the test area, and only at that point could the chimpanzee exchange each accumulated lexigram token for the food item it represented. Completion of a trial-block required approximately 2.5 min and there was a four-min interval between each block of trials. Each chimpanzee completed four sessions in this phase.

2.4. Compliance

This research complied with protocols approved by the Institutional Animal Care and Use Committee of Georgia State University. The research adhered to the legal requirements of the United States of America and to the American Society of Primatologists (ASP) Principles for the Ethical Treatment of Non Human Primates.

3. Results

In Phase 1 when two food items were always presented (Trials 1–4), the chimpanzees chose the pre-established higher value item on all trials (100%). In Trials 5–8, when two tokens were always presented, Sherman and Panzee selected the higher value token on 100% of the trials, and Lana did so on 91.67% of trials. Thus, the chimpanzees gave clear behavioral evidence that they preferred *M&M*s and bananas to bread and apples both when all choice options could be consumed immediately and when consumption was delayed for all options by 10–15 seconds because of the need to transport and exchange tokens for actual foods.

Figure 1 shows performance for each chimpanzee on the mixed (food vs. token) trial types presented in Phase 1 (Trials 9–16 of each session). In these trials, all three chimpanzees made the response that gained them the higher preference food at levels significantly above chance (Sherman – 79.16%, Panzee – 87.5%, Lana – 91.67%; all $P < 0.01$ as assessed with two-tailed binomial tests). Within these trials, when the more preferred item was an immediately consumable food item, chimpanzees selected the higher value item in a large proportion of trials (Sherman – 91.67%, Panzee – 91.67%, Lana – 83.33%; all $P < 0.01$, binomial tests). Critically, when the more preferred item was a lexigram token, Panzee and Lana also chose the more preferred item at levels significantly better than chance (Panzee – 83.33%, Lana – 100%; both $P < 0.01$, binomial tests). Sherman, however, selected the more preferred token on 66.67% of trials, but this did not differ from chance ($P > 0.05$, binomial test). Thus, without explicit training, most chimpanzees selected tokens over food items when such a response led to better food for consumption, and they did so even though token selections resulted in slightly delayed food consumption.

In Phase 2, trial-blocks lasted for 2–3 min (Sherman - 167 s, Panzee - 176 s, Lana - 160 s). Chimpanzees' performance was more variable in Phase 2 than in Phase 1, and these results are presented in Figure 2. In this phase, increasing the delay before tokens could be traded for food items had detrimental effects, at least initially, for some chimpanzees. Initially, Sherman was significantly more likely to choose the less preferred food which he could eat immediately (Sessions 1 and 2, $P < 0.05$, binomial tests). However, later in the phase he was indifferent between the two options and was accumulating tokens for later trade as often as he was choosing the less preferred food item to eat immediately. Panzee began this phase indifferent between the tokens and food items, as she selected tokens on about half of the trials in Sessions 1 and 2. However, in the last two sessions, she showed a significant

preference to choose the tokens rather than eat the immediately available food items ($P < 0.05$, binomial tests). Lana showed the best performance, choosing the token at levels significantly higher than chance in all four sessions ($p < .05$, binomial tests). Thus, compared to Phase 1, in which tokens could be immediately exchanged for foods, self-control performance in Phase 2 initially suffered due to the delay between token acquisition and exchange. But, performance recovered for one chimpanzee, who then reverted to selecting the delayed rewards over the immediately available, less preferred reward.

Once concern in Phase 2 was that perhaps the chimpanzees would become satiated as sessions progressed, and thus they may have begun selecting the token more often. This would be a different reason for the apparent self-control shown. Thus, we assessed the number of selections of the token over the food for each chimpanzee for the first 15 trials of all four sessions and the second 15 trials of all four sessions. Here, the prediction was that if satiation was occurring, there would be more selections in the second 15 trials of each session than in the first. However, this was not true. None of the animals showed a significant difference in choice of the tokens in the two blocks of 15 trials (Sherman X^2 (1, $N = 60$) = 2.98, $P > .05$; Panzee X^2 (1, $N = 60$) = 3.26, $P > .05$; Lana X^2 (1, $N = 60$) = 1.00, $P > .05$).

A concern raised during review of this paper was that perhaps the chimpanzees were not faced with prepotent response options if there was no evidence that real food was preferred to tokens for the same food type. Thus, we conducted a post hoc test session in which we gave each chimpanzee 12 trials. In this session, they completed three trials with each pairing of real food items and lexigram tokens of those same food items (banana versus lexigram for banana, bread versus lexigram for bread, M&M versus lexigram for M&M, and apple versus lexigram for apple). Sherman and Panzee selected the real food on every one of those trials. Lana selected the real food in 8 of 12 trials. Three of her four selections of a lexigram over a food item were for the bread lexigram over the actual piece of bread (and she later would not eat the bread when she obtained it by trading her tokens). The other was Trial 1, where she picked the apple lexigram over real apple, possibly as a result of having not seen these tokens in quite some time. She corrected that, and selected the apple itself on the next two presentations. Overall, with just one food exception for one chimpanzee, food was always preferred over lexigram tokens representing the same food, but with a delay to delivery.

4. Discussion

In this experiment, chimpanzees showed clear preferences among a set of food options and their preferences were unchanged when all food options were represented by symbolic tokens that had to be exchanged with an experimenter in order to obtain the actual rewards. Further, when these primary and secondary reward types were paired, chimpanzees demonstrated that they could inhibit prepotent responses to the immediately available food items and instead select the tokens that could be traded later for better foods. All three animals did so when the token exchange process delayed food consumption by a matter of seconds, and two of the three did so after some trials even when tokens could only be exchanged for food rewards at the end of a 2–3 minute long session.

Chimpanzees have shown previous success in other self-control and delay of gratification paradigms [e.g., Beran et al., 1999; Beran, 2002; Rosati, Stevens, Hare, & Hauser, 2007]. In one of those studies [Rosati et al., 2007], chimpanzees chose between two visible food options, the smaller of which could be consumed immediately, and the larger of which could be consumed after a delay. Thus, the general procedure of that study was similar to the design of the present study, with the exception of the more preferred option being a visible food option (rather than a symbolic representation of that food). Interestingly, in that task,

chimpanzees became indifferent between the two food options when the delay to the greater option was a mean of 122.6 s (SE = 15.9 s), which is notably (although possibly not significantly) shorter of a duration than the wait time imposed upon the chimpanzees in the present study (160–176 s). Therefore, a direct comparison of chimpanzee performance in these related self-control tasks is warranted and may yield interesting conclusions about the benefit of symbolic reward representations in this paradigm (and these may be similar to what has been found in the reversed-reward task and the delay of gratification paradigm, as described above).

That tokens were chosen over food items in the present study indicates that chimpanzees presumably understood that the tokens, although not edible themselves, would be valuable later for exchange for food that was more preferred. This result matched previous studies with these animals in showing that lexigrams can operate to support intelligent decision making [e.g., Beran et al., 1999; Brosnan & Beran, 2009]. However, this study is the first to require chimpanzees to select and collect lexigrams, with no immediate value, so that they could later be used to obtain food items of greater value than presently available alternatives. This is an important finding because it shows that abstract representation of rewards is possible for animals in this scenario and also that those representations can provide a means for exhibiting self-control and delay of gratification [see also Boysen & Berntson, 1995]. Although the delays used here were modest in duration, if chimpanzees were also willing to work for tokens only exchangeable much (e.g., hours) later in time, such a result would have implications for understanding how the use of currency and other exchangeable commodities may have emerged in human evolution.

This experiment also provides evidence that primates can make decisions and evaluate task contexts in ways that go beyond making simple responses to prepotent and immediately available items such as food. Boysen and colleagues [e.g., Boysen & Berntson, 1995; Boysen et al., 1996] have shown elegantly that substituting symbols for all food rewards in a task reduces the prepotency of certain choice options so that chimpanzees can obtain a better outcome. The chimpanzees in the present experiment also made profitable decisions in a task involving symbolic rewards, and they did so in a scenario in which responses to actual immediately consumable food items were directly pitted against better long-term options represented by symbolic tokens. The chimpanzees showed self-control in this presumably difficult task and anticipated that future trading opportunities were sufficiently motivating to forgo foods that could be eaten immediately.

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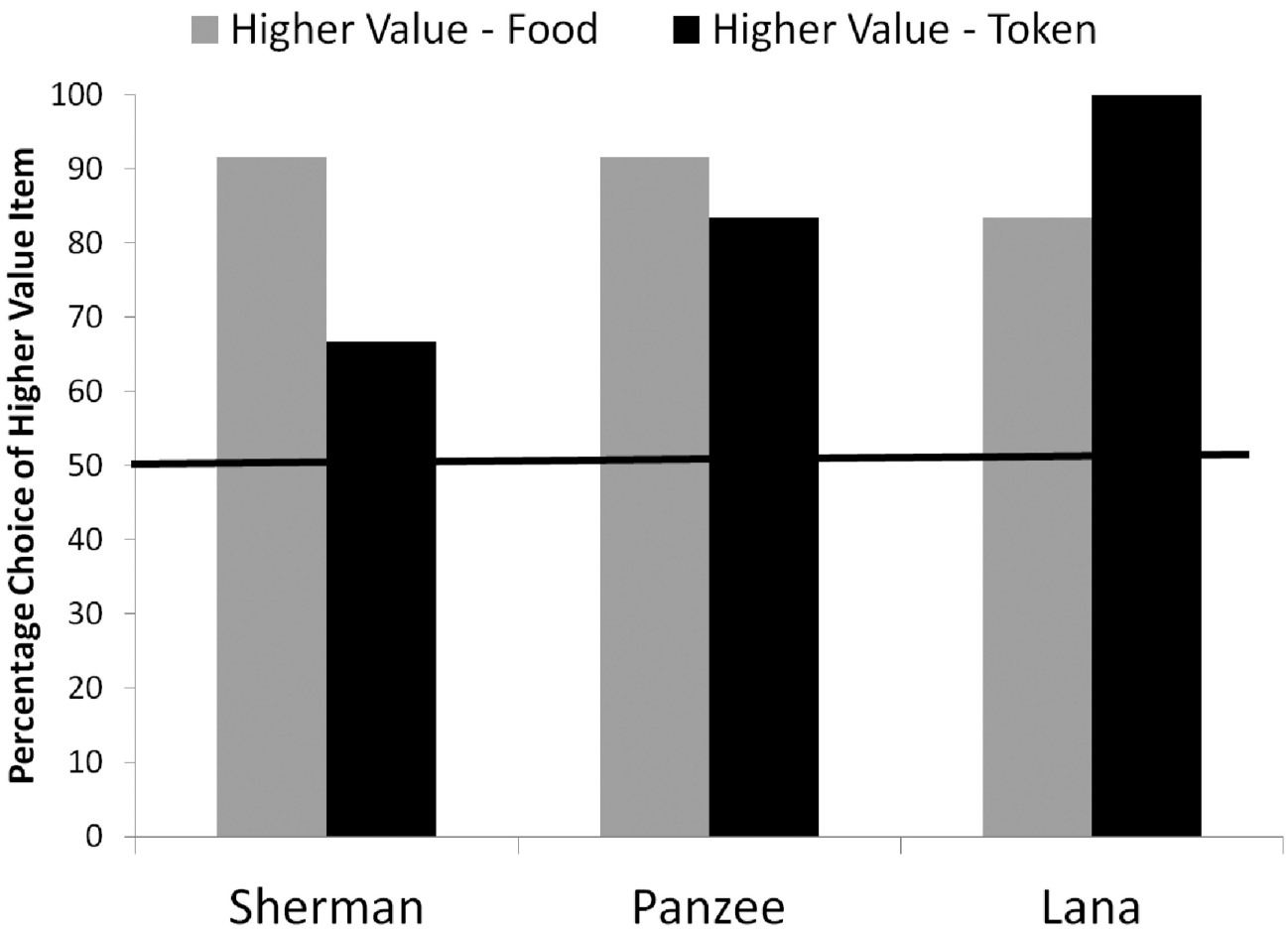

Figure 1.
Chimpanzees' performance in Phase 1 in which they choose between a lexigram token and visible food item of differing preference value. Gray and black bars represent trials in which the visible food item or the lexigram token was of greater value, respectively. The horizontal line represents the level for indifference in choice.

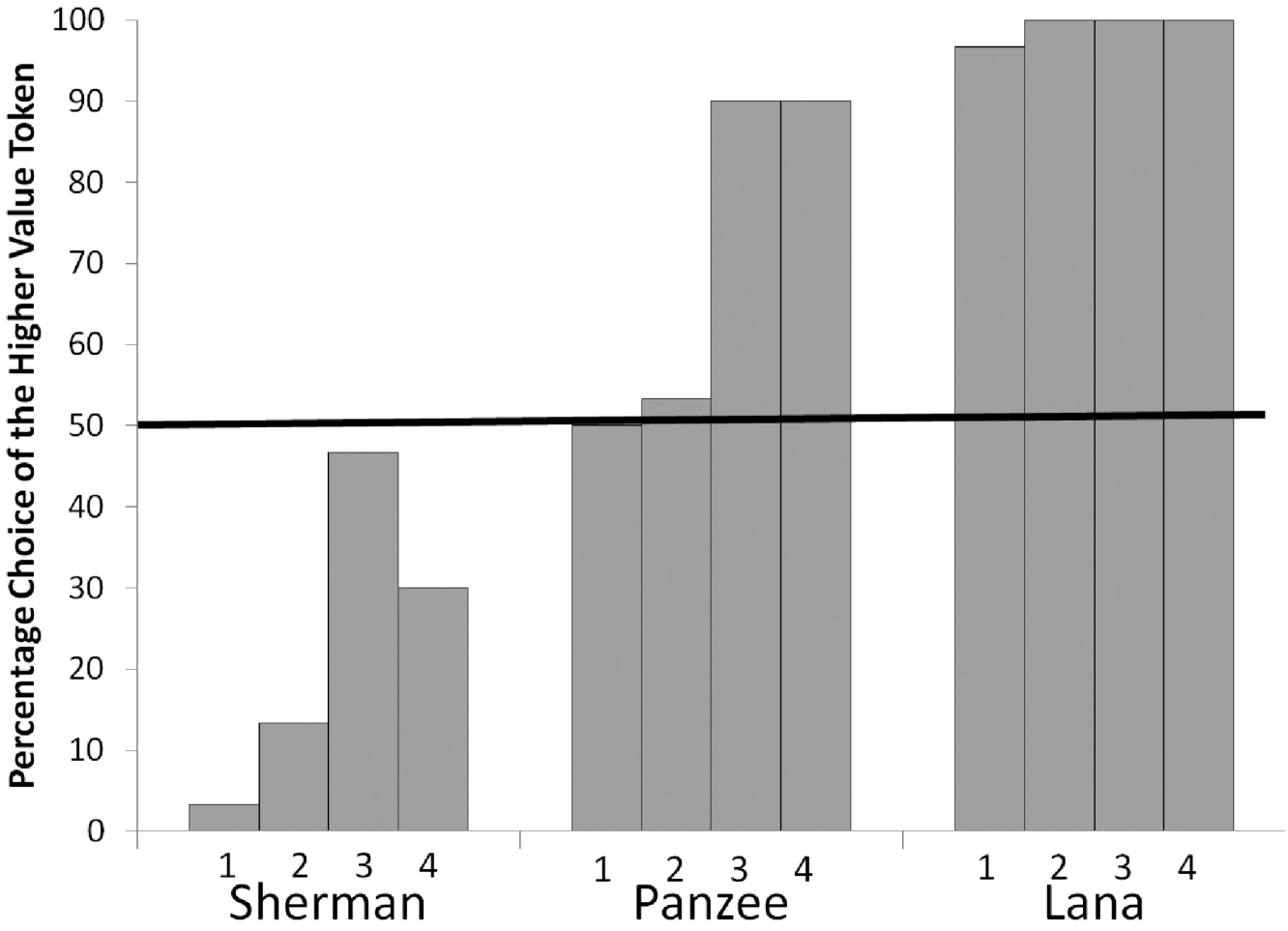

Figure 2.
Chimpanzees' choice of a higher value token over a lower value visible food item in Phase 2 as a function of session number (shown on the x-axis). The horizontal line represents the level for indifference in choice.