

Delay Choice Versus Delay Maintenance: Different Measures of Delayed Gratification in Capuchin Monkeys (*Cebus apella*)

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Delaying gratification involves 2 components: (1) delay choice (selecting a delayed reward over an immediate one) and (2) delay maintenance (sustaining the decision to delay gratification even if the immediate reward is available during the delay). Two tasks most commonly have explored these components in primates: the intertemporal choice task and the accumulation task. It is unclear whether these tasks provide equivalent measures of delay of gratification. Here, we compared the performance on the intertemporal choice task and the accumulation task of capuchin monkeys (*Cebus apella*) belonging to 2 study populations. We found only limited evidence of a significant correlation in performance. Consequently, in contrast to what is often assumed, our data provide only partial support for the hypothesis that these tasks provide equivalent measures of delay of gratification.

Keywords: delay of gratification, intertemporal choice, delay maintenance, capuchin monkeys, *Cebus apella*

Delay of gratification involves foregoing an immediate reward to obtain a better but future reward. It is a prerequisite for complex goal-directed action (Mischel, 1974), and it has often been considered one of the features distinguishing humans from other animals (but see

Rosati, Stevens, Hare, & Hauser, 2007). Delaying gratification involves two components: (1) delay choice (selecting a delayed reward over an immediate one) and (2) delay maintenance (sustaining the decision to delay gratification even if the immediate reward remains available during the delay; e.g., Toner & Smith, 1977).

A traditional paradigm to measure delay choice is the *intertemporal choice (ITC) task* (sometimes also labeled as the *self-control task*; e.g., Stevens, 2010), in which the subject chooses between a smaller and sooner option and a larger delayed option; once the choice is made, there is no possibility to change it (Mazur, 1988). In contrast, methods to assess delay maintenance, such as the accumulation task, require sustained waiting for a larger or better option throughout the entire delay. In this task, food items are accumulated at a fixed rate in front of the subject, but such accumulation stops whenever the subject takes those items. So, to obtain the whole amount, the subject has to refrain from taking the items already available until the end of the accumulation process (e.g., Anderson, Kuroshima, & Fujita, 2010; Beran, 2002; Beran & Evans, 2006; Evans & Beran, 2007; Pelé, Dufour, Micheletta, & Thierry, 2010; Pelé, Micheletta, Ulrich, Thierry, & Dufour, 2011; Toner & Smith, 1977).

Although some authors agree that impulsivity is a multifaceted phenomenon (Cardinal, 2006; Evenden, 1999), delay choice and delay maintenance are often regarded as though they represent equivalent processes (e.g., Evenden & Ryan, 1996; Green, Fry, & Myerson, 1994; Johnson & Bickel, 2002; Mischel, Shoda, & Rodriguez, 1989) or as measuring the same process (Rachlin, 2000). However, there is evidence suggesting that delay choice and delay maintenance procedures are not equivalent (Reynolds & Schiffbauer, 2005). When delay choice and delay maintenance were compared in rats using a between-subjects design, the two groups showed some differences in performance (Reynolds, de Wit, & Richards, 2002). In a recent study with capuchin monkeys

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using a new paradigm that combines delay choice and delay maintenance within the same task, many capuchins that chose the larger delayed reward were nonetheless unable to sustain the ensuing delay if given the opportunity to revise their choice prior to reward delivery (Paglieri et al., in press). Moreover, because serotonin lesions impair performance in delay maintenance tasks but not in delay choice tasks (Richards, Chock, & de Wit, 1998), it is likely that different neural mechanisms underlie the two processes (see also Evenden, 1999). Furthermore, in preschool-age children, there is clear evidence of an age-related increase in performance on delay maintenance tasks but not on delay choice tasks (Schwarz, Schrager, & Lyons, 1983). In a study in which a delay choice task and a delay maintenance task were administered to 3- to 5-year-old children, performances were negatively correlated for girls and positively correlated for boys (Toner, Holstein, & Heterington, 1977).

In light of these differences between delay choice and delay maintenance tasks, it is surprising that no study has yet directly compared performance between these tasks in nonhuman primates. From the limited evidence available in the literature, it would seem that some species might perform relatively well in the ITC task but relatively poorly in the accumulation task. For instance, capuchin monkeys seem highly proficient in the ITC task (Addessi, Paglieri, & Focaroli, 2011) but not in the accumulation task (e.g., Anderson et al., 2010); conversely, long-tailed macaques perform relatively poorly in the ITC task (Amici, Aureli, & Call, 2008; Tobin, Logue, Chelonis, Ackerman, & May, 1996), but are somewhat proficient in the accumulation task (Pelé et al., 2010). Among nonhuman primates, only for chimpanzees is there substantial evidence of good performance both in the ITC task (Rosati et al., 2007) and in the accumulation task (e.g., Beran, 2002; Beran & Evans, 2006; Evans & Beran, 2007). However, it is difficult to compare independent studies testing the same species on these two tasks because only a few species have been tested on both tasks, and often there are methodological differences that hinder conducting a clear comparison.

Thus, as some authors have pointed out (e.g., Reynolds et al., 2002; Reynolds & Schiffbauer, 2005), a direct comparison across delay choice and delay maintenance tasks within the same population is needed. Here, we tested capuchin monkeys in an ITC task with a fixed delay procedure and in an accumulation task. If the tendency to consider these tasks as providing equivalent measures of delay of gratification is valid (e.g., Rachlin, 2000), one would expect capuchins' performance to correlate positively across these two tasks. Alternatively, if delay choice and delay maintenance tasks measure different aspects or kinds of delay of gratification, capuchins' performance in the ITC task might diverge from the performance of the same capuchins in the accumulation task. To our knowledge, this is the first study directly comparing different delay of gratification tasks in the same population of nonhuman primates.

Method

Subjects

We tested 18 capuchin monkeys (*Cebus apella*). Ten capuchins were housed at the Primate Center of the Istituto di Scienze e Tecnologie della Cognizione, Rome, and eight were housed at the Language Research Center of Georgia State University. In Rome, we tested five males and five females (mean age = 17 years,

range = 9–29 years). Each group was housed in indoor–outdoor compartments (total area: 53.2–374.0 m³, depending on group size) and tested in one testing compartment (0.99 m³). Rome capuchins had previous experience in several cognitive tasks, including an ITC task with an adjusting delay procedure (Addessi et al., 2011). This study complied with protocols approved by the Italian Health Ministry, and all procedures were performed in full accordance with European law on humane care and use of laboratory animals.

In Atlanta, we tested five males and three females (mean age = 11 years, range = 5–20 years). Capuchins were group housed with indoor–outdoor access, but were separated into individual 33- × 46- × 61-cm enclosures for testing. The test area included four side-by-side test enclosures (each separated from the next by a distance of 66 cm) so that capuchins maintained visual and auditory access to other capuchins even while physically separated for testing. Atlanta capuchins had previous experience in several cognitive tasks but had not been previously tested in these delay of gratification tasks. This study complied with protocols approved by the Georgia State University Institutional Animal Care and Use Committee. All procedures were performed in full accordance with the U.S. Department of Agriculture Animal Welfare Act and conformed to the “Guidelines for the Treatment of Animals in Behavioral Research and Teaching” (Animal Behavior Society, 2012).

In both laboratories, capuchins had 24-hr access to water and were fed manufactured chow and various fruits and vegetables in the afternoon after testing was completed.

Apparatus

In Rome, in the ITC task, two quantities of food were presented on an apparatus consisting of a platform (65 × 40 × 16 cm) with two transparent boxes (9.5 × 20 × 15 cm each), 28 cm apart, each containing a horizontal sliding panel (7.7 × 27 cm). Capuchins could choose one of the two options by inserting their finger in a small hole (diameter: 2 cm) located in the appropriate box. Capuchins reached the apparatus through one of two openings in the wire mesh (8.5 cm × 3.8 cm each) that were aligned with the boxes. Individual choices were scored during the experiment and all sessions were videotaped.

In Atlanta, the apparatus consisted of a rolling cart (52.5 × 68.5 × 85 cm high) with a sliding shelf (34 × 48 cm) placed in front of the testing compartment. Between the cart and the compartment was a Plexiglas panel (56.6 × 74 cm) with two small poke holes through which capuchins could point to make a selection.

In both laboratories, in the accumulation task, the apparatus was a vertical Plexiglas panel (56.6 × 74 cm) inserted in place of one of the three vertical mesh walls of the testing compartment. A Plexiglas pan (25 × 6.5 cm), in which the food items were placed, was attached on the experimenter's side at 14.5 cm from the bottom of the panel. The experimenter could either lock or unlock the pan by sliding a deadbolt; when it was unlocked, capuchins could pull the pan into their side of the panel.

Design and Procedure

ITC task. Capuchins faced a series of choices between two food items, available immediately, and six food items, available after 80 s. Food items consisted of one eighth of a peanut seed each in Rome and 45-mg banana-flavored, grain-based pellets (Bio-Serv, Frenchtown, NJ) in Atlanta. Each experimental session consisted of four forced-choice trials (with only one option available) for familiarization and six binary choice trials. The first two forced-choice trials (one with the small reward and one with the large one) were presented at the beginning of each session, alternating their order and position between sessions. The remaining two trials were randomly interspersed throughout the session. The order and the position of the six binary choice trials were pseudorandomized throughout the session. The intertrial interval was 30 s. The ITC task was carried out between January and July 2010.

Capuchins were tested until their preferences stabilized, that is, until the number of times capuchins chose the larger option did not differ by more than one unit for five consecutive sessions, or until they received 10 sessions without reaching this preference stability. Thus, a different number of sessions was completed by each capuchin, depending on whether and when the criterion was reached. We analyzed the last five sessions for all capuchins. Specifically, for those capuchins whose choices reached stability within 10 sessions, we considered the means for the five sessions that met the stability criterion, whereas for those capuchins whose choices did not reach stability within 10 sessions, we considered the means for the last five sessions.

Accumulation task. In the accumulation task, the experimenter transferred one food item every 2 s from a container beyond reach of the capuchin to the Plexiglas pan within reach of the capuchin. The capuchin could wait until all the items were transferred or wait less and take a smaller number of items, at which point no more items accumulated and the trial ended. As soon as the capuchin took the first item, the experimenter interrupted the accumulation process (and no further items were delivered). The items to be transferred into the pan were visible to the capuchin at the start of the trial and remained visible throughout the trial. The accumulation task data with the Atlanta capuchins were collected during a previous investigation of delay of gratification with appetitive and symbolic rewards (Evans, Beran, Paglieri, & Addessi, 2012), although those data have not previously been compared with data on the ITC task.

The accumulation task involved two phases: (1) five-item accumulation phase and (b) 50-item accumulation phase. All capuchins first completed the five-item accumulation phase and then the 50-item accumulation phase. Food items were the same as those used in the ITC task. In each trial of the five-item accumulation phase, the experimenter transferred a maximum of five items to the Plexiglas pan, one at a time. Each session consisted of four trials: one forced-accumulation trial for familiarization (presented at the beginning of the session), in which the Plexiglas pan was locked and the experimenter accumulated all five items before unlocking the pan and allowing the capuchin to take all the items, and three free-accumulation trials, in which the Plexiglas pan was unlocked and the capuchin had access to the accumulating items throughout the ac-

cumulation process. The five-item accumulation phase consisted of eight sessions.

In each trial of the 50-item accumulation phase, the experimenter transferred a maximum of 50 items to the Plexiglas pan. Each session consisted of two free-accumulation trials, in which the Plexiglas pan was unlocked and the capuchin had access to the accumulating items throughout the accumulation process. The 50-item accumulation phase consisted of 10 sessions.

In Rome, there was an intertrial interval of 30 s. In Atlanta, we presented each trial to each of four capuchins before moving on to the next trial (because these capuchins were housed in four adjacent enclosures during testing). This created a variable intertrial interval for a particular capuchin, ranging from approximately 45 to 90 s, depending on the performance of the other three capuchins being tested. The accumulation task was carried out between July and December 2010.

Results

As shown in Table 1, for both tasks, there was a significant difference in performance between populations. Specifically, a Mann–Whitney U test indicated that Atlanta capuchins chose the delayed option more (in the ITC task) and accumulated more items (in the accumulation task) than Rome capuchins (ITC task: $U = 2.00$, $p < .001$; accumulation task, five-item accumulation phase: $U = 4.00$, $p < .001$; accumulation task, 50-item accumulation phase: $U = 5.00$, $p < .001$). Thus, all statistical analyses were performed separately on each population.

As shown in Table 2, in the ITC task, for most capuchins there was no significant improvement in performance across sessions; instead, for two capuchins (Carlotta and Griffin), there was a marginally significant decrease in performance, and for one capuchin (Sandokan), the decrease reached significance. When analyzing the data at the population level, a Wilcoxon signed-ranks test indicated that Rome capuchins chose the larger delayed option significantly less in the second half than in the first half of the trials (first half: median = 51.7, interquartile range = 23.1; second half: median = 43.9, interquartile range = 37.5; $T = 5.00$, $p = .02$), whereas for Atlanta capuchins, this difference was not significant (first half: median = 77.5, interquartile range = 10.4; second half: median = 74.4, interquartile range = 9.17; $T = 11.5$, $p = .67$). As shown in Table 3, in the five-item accumulation phase of the accumulation task, performance significantly improved over time for four of 10 Rome capuchins and for seven of eight Atlanta capuchins, whereas in the 50-item accumulation phase, performance improved over time for only two capuchins (Drella and Wren) and significantly decreased for one capuchin (Nala). When analyzing the data at the population level, it emerged that in the five-item accumulation phase, Atlanta capuchins accumulated significantly more items in the second half than in the first half of the trials (first half: median = 1.58, interquartile range = 1.04; second half: median = 4.50, interquartile range = 0.42; $T = 0.00$, $p = .018$), whereas for Rome capuchins, this difference was not significant (first half: median = 1.00, interquartile range = 0.21; second half: median = 1.11, interquartile range = 0.68; $T = 20.00$, $p = .44$). In the 50-item accumulation phase for Rome capuchins, there was a marginally significant decrease in the number of items accumulated in the second half compared with the first half of the trials (first half: median = 1.05, interquartile range = 1.10; second

Table 1
Performance of Each Capuchin Monkey in the Two Experiments

Subject	Laboratory	Sex	Intertemporal choice task	Accumulation task (5-item phase)	Accumulation task (50-item phase)
Carlotta	Rome	F	66.7 ± 11.8	1.04 ± 0.04	1.00
Gal	Rome	M	20.0 ± 3.30	1.96 ± 0.34	1.00
Pedro	Rome	M	43.3 ± 4.10	1.33 ± 0.16	1.10 ± 0.10
Pippi	Rome	F	50.0 ± 0	1.00	1.05 ± 0.05
Roberta	Rome	F	43.3 ± 4.10	1.00	1.05 ± 0.05
Robin Hood	Rome	M	56.7 ± 11.30	1.00	1.00
Robot	Rome	M	10.0 ± 6.70	1.83 ± 0.38	4.45 ± 0.41
Rubens	Rome	M	66.7 ± 5.30	2.33 ± 0.39	4.20 ± 0.68
Sandokan	Rome	M	20.0 ± 3.30	2.21 ± 0.48	1.90 ± 0.51
Saroma	Rome	F	20.0 ± 6.20	1.08 ± 0.07	1.00
Mean ± SEM			39.7 ± 6.60	1.48 ± 0.17	1.78 ± 0.43
Drella	Atlanta	M	73.3 ± 4.10	1.42 ± 0.10	2.38 ± 0.20
Griffin	Atlanta	M	76.7 ± 4.10	2.75 ± 0.38	3.50 ± 0.42
Lily	Atlanta	F	80.0 ± 3.30	3.63 ± 0.32	8.13 ± 0.90
Wren	Atlanta	F	80.0 ± 3.30	4.50 ± 0.24	10.94 ± 1.10
Gabe	Atlanta	M	93.3 ± 4.10	3.13 ± 0.34	5.38 ± 0.46
Liam	Atlanta	M	76.7 ± 11.3	3.50 ± 0.34	9.88 ± 1.26
Logan	Atlanta	M	70.0 ± 6.20	2.67 ± 0.39	6.88 ± 0.54
Nala	Atlanta	F	63.3 ± 13.3	2.71 ± 0.35	4.25 ± 0.46
Mean ± SEM			76.7 ± 3.10	3.04 ± 0.32	6.42 ± 1.09

Note. Mean percentages of “larger later” choices ± SEM in the intertemporal choice task and mean number of items accumulated ± SEM in the 5-item accumulation phase and 50-item accumulation phase of the accumulation task are reported. For the intertemporal choice task, we report either the means for the sessions that met the stability criterion (for those capuchins whose choices reached stability within 10 sessions) or the means for the last 5 sessions (for those capuchins whose choices did not reach stability within 10 sessions; see Method section).

half: median = 1.00, interquartile range = 0.32; $T = 1.50$, $p = .059$), whereas for Atlanta capuchins, this difference was not significant (first half: median = 5.65, interquartile range = 4.45; second half: median = 6.35, interquartile range = 4.48; $T = 12.00$, $p = .40$).

For Atlanta capuchins, there was a significant correlation between the number of item accumulated in the five-item accumu-

lation phase and in the 50-item accumulation phase ($r_s = .81$, $p = .01$), but this did not hold true for Rome capuchins ($r_s = .52$, $p = .12$).

As shown in Table 4, for both Rome and Atlanta capuchins, the percentage of delayed choices made by each individual in the ITC task did not significantly correlate with the mean number of food

Table 2
Correlation Between Number of Delayed Choices in the Intertemporal Choice Task and Number of Sessions for Each Capuchin Monkey

Subject	r_s	p	Sessions (n)
Carlotta	-.47	.07	15
Pedro	.24	.54	9
Gal	-.48	.14	11
Pippi	-.10	.79	10
Roberta	-.31	.55	6
Robin Hood	-.31	.15	23
Robot	-.44	.17	11
Rubens	.23	.50	11
Sandokan	-.84	.03	6
Saroma	-.43	.12	14
Drella	-.29	.64	5
Griffin	-.87	.06	5
Lily	.13	.72	10
Wren	.71	.18	5
Gabe	.46	.35	6
Liam	.23	.53	10
Logan	-.26	.48	10
Nala	-.38	.28	10

Note. Values in bold denote marginally significant ($p < .10$) or significant ($p < .05$) correlations.

Table 3
Correlation Between Number of Items Accumulated in Each Phase of the Accumulation Task and Number of Sessions

Subject	5-item phase			50-item phase		
	r_s	p	Sessions (n)	r_s	p	Sessions (n)
Carlotta	.41	.31	8	— ^a	—	10
Pedro	.00	1.0	8	-.52	.12	10
Gal	.71	.05	8	— ^a	—	10
Pippi	— ^a	—	8	-.41	.24	10
Roberta	— ^a	—	8	.06	.87	10
Robin Hood	— ^a	—	8	— ^a	—	10
Robot	.80	.02	8	-.36	.31	10
Rubens	.93	<.001	8	.10	.79	10
Sandokan	.95	<.001	8	-.38	.28	10
Saroma	.58	.13	8	— ^a	—	10
Drella	-.15	.71	8	.65	.04	10
Griffin	.91	.001	8	.41	.24	10
Lily	.89	.003	8	.49	.15	10
Wren	.76	.03	8	.63	.05	10
Gabe	.77	.02	8	.41	.24	10
Liam	.71	.05	8	-.47	.17	10
Logan	.86	.007	8	.17	.64	10
Nala	.97	<.001	8	-.72	.02	10

Note. Values in bold denote significant ($p < .05$) correlations.

^a These capuchins accumulated only one item in all sessions, so the correlations were not performed.

Table 4
Spearman Correlations Between Percentages of "Larger Later" Choices in the Intertemporal Choice Task and Mean Number of Items Accumulated in Each Phase of the Accumulation Task

Group	5-item accumulation phase		50-item accumulation phase	
	All capuchins	Capuchins who accumulated >1 item	All capuchins	Capuchins who accumulated >1 item
Rome capuchins	$r_s = -.28$ $N = 10$ $p = .43$	$r_s = -.07$ $n = 7$ $p = .87$	$r_s = -.22$ $N = 10$ $p = .55$	$r_s = -.37$ $n = 6$ $p = .47$
Atlanta capuchins	$r_s = .73$ $N = 8$ $p = .04$	—	$r_s = .42$ $N = 8$ $p = .29$	—

Note. Accumulation results for the Atlanta capuchins come from a previous study of delay of gratification (Evans et al., 2012). For Rome capuchins, we carried out the analysis considering all capuchins and only those who accumulated more than one item. All Atlanta capuchins accumulated more than one item. Values in bold denote significant ($p < .05$) correlations.

items accumulated by the same capuchins in the 50-item accumulation task, and this was also true for the Rome capuchins in the five-item accumulation task. For the Rome group, this finding held true both when analyzing the data for all capuchins and when considering only the data for those capuchins who accumulated on average more than one item (i.e., excluding the capuchins whose performance was at floor). The only significant correlation occurred for the ITC task and the five-item accumulation task for the Atlanta group of capuchins.

Discussion

Although we employed as much as possible a common methodology with the two study groups, Atlanta and Rome capuchins differed in their performance in both the ITC and the accumulation tasks. In particular, Atlanta capuchins chose the larger delayed option significantly more in the ITC task and accumulated significantly more items in the accumulation task than Rome capuchins. The fact that two different groups of capuchins showed two different levels of success in these paradigms, despite being tested with similar protocols, could either be due to fine-grained differences in methodology or to different previous testing experience.

Indeed, although the methods used in Rome and Atlanta were rather similar, there were several differences in the laboratory testing environment that could well be responsible for the different performances. Most notably, Atlanta capuchins had visual and auditory access to other capuchins while they were being tested, whereas Rome capuchins did not. Capuchins were tested this way because this is the general procedure that they were accustomed to at each laboratory. Nevertheless, it is possible that this resulted in Atlanta capuchins having more opportunities for distraction that potentially could have facilitated their performance in both tasks. Opportunities for distraction have in fact proven beneficial to human and chimpanzee participants in delay maintenance tasks in previous reports (Evans & Beran, 2007; Miller & Karniol, 1976; Mischel, Ebbesen, & Zeiss, 1972; Toner & Smith, 1977) by diverting their attention away from accessible rewards.

These two capuchin groups also had different previous testing experiences. Although both groups participated in multiple prior cognitive studies, only the Atlanta capuchins had extensive training and testing experience with computerized test systems and

joystick response inputs (Evans, Beran, Chan, Klein, & Menzel, 2008). Joystick use necessarily instills some degree of behavioral inhibition because animals must learn to act behaviorally in ways that are not prepotent. Thus, because of their computer and joystick training, Atlanta capuchins may be more capable of succeeding in tests like those used in the present experiment. At the same time, Rome capuchins previously had taken part in an ITC task with an adjusting delayed procedure (Addessi et al., 2011), and their earlier experience could have affected their performance in the ITC task (see below for further discussion).

Moreover, whereas for the Atlanta capuchins there was a significant correlation in performance between the two phases of the accumulation task (i.e., the five-item phase and the 50-item phase), for the Rome capuchins, this was not the case. It can be hypothesized that in the 50-item accumulation phase, individuals may react in different ways to the view of a larger amount of food. They could (a) continue to accumulate on average the same amount of food as in the five-item accumulation phase, (b) accumulate more food because they see a larger amount of food potentially available and wait to accumulate some specific proportion of that amount (Anderson et al., 2010), or (c) accumulate less food because they are somehow distracted by seeing the larger amount of food. The Atlanta capuchins' performance suggests that when more food could be obtained, they waited longer than when less food could be obtained, but we cannot state what made this group more successful than the Rome capuchins other than to note that the two conditions may have differentially impacted the two groups.

Notwithstanding these group differences, we found only limited evidence of a significant correlation between capuchins' performance in the ITC task and in the accumulation task, which is in agreement with the hypothesis proposed by other researchers that these tasks measure different facets of impulsivity (e.g., Evenden, 1999; Reynolds et al., 2002; Reynolds & Schiffbauer, 2005; Richards et al., 1998). There was a significant correlation between the Atlanta capuchins' performance in the ITC task and in one of the two conditions of the accumulation task (five-item phase), but this did not hold true for this same population in the other condition of the accumulation task (50-item phase) or for the Rome capuchins in both conditions of the accumulation task. Thus, in three cases of

four, there was no correlation in performance between the ITC task and the accumulation task.

The limited evidence of a correlation between the ITC task and the accumulation task cannot be due to a poor understanding of the contingencies of the accumulation task itself. In fact, most capuchins showed an initial improvement of performance in this task (see also Evans et al., 2012), demonstrating that they learned and understood its contingencies. The small size of our samples and the little variance exhibited by the Rome capuchins in the accumulation task do not seem a major issue. In fact, the only significant correlation between performance in the ITC task and in the accumulation task was found for the Atlanta capuchins, which was the population with the smaller sample size, in the condition with the smaller variance (i.e., the five-item accumulation phase). Moreover, although some of the Rome capuchins did not accumulate more than one item in either phase of the accumulation task, no correlation with the ITC task emerged when we excluded from the analyses these very impulsive capuchins.

These findings provide only partial support for the hypothesis that these tasks provide equivalent measures of delay of gratification. This may be because the ITC task measures choice preference, a higher order cognitive process involving the evaluation of several factors (e.g., delay length, magnitude or quality differences between the options), whereas the accumulation task measures behavioral inhibition, a more basic and less learning-mediated process (Reynolds & Schiffbauer, 2005). Moreover, in the ITC task, participants are committed to their choice after making it; in contrast, in the accumulation task, participants need to sustain their choice of waiting for obtaining the whole reward during the entire duration of the delay because they can alter their initial choice to wait anytime during the accumulation process by taking the accumulated reward.

It is also possible that some forms of the ITC task may be flawed when they involve choices between appetitive stimuli such as food items. When animals are choosing between two visible food quantities, one of those options is particularly tempting because of its greater size/amount. Although it is commonly assumed that choosing the larger delayed option in the ITC task expresses good performance in terms of delaying gratification, it might be that these alleged “self-control responses” are in fact failures at inhibiting a prepotent response toward the larger quantity. Here, an animal that looks like it is showing high levels of delayed gratification could, in fact, find it too difficult to inhibit responses to the more salient (i.e., larger) amount of food. Thus, some versions of the ITC task may confound delay of gratification and lack of inhibition to prepotent stimuli (for a discussion, also see Addessi et al., 2012; Bramlett, Perdue, Evans, & Beran, 2012). This hypothesis seems supported by the decrease in ITC performance observed in some of our capuchins. This pattern of behavior is hard to interpret if one assumes that choosing the larger delayed option expresses good performance in terms of delaying gratification. If that was the case, then animals should improve their performance over time, instead of getting worse. Instead, it appeared that some capuchins learned to overcome the prepotent response toward the larger quantity because they chose the larger option less frequently later in the experiment, revealing their “true” temporal preferences. The above hypothesis is also supported by the fact that in the ITC task, Rome capuchins (which had previous experience in

another version of this task) had an overall lower performance than Atlanta capuchins (which lacked such experience).

Additional confirmation of this potential flaw in the ITC task is found in previous data on chimpanzees (Rosati et al., 2007). When comparing the performance of chimpanzees and humans in an ITC task with a fixed delayed procedure, Rosati and colleagues (2007) reported that chimpanzees chose the larger delayed option significantly more than adult humans tested in similar conditions. However, of the 19 chimpanzees tested in that study, only five had already participated in a previous ITC task with an adjusting delay procedure. Thus, when comparing the performance of the five expert chimpanzees with that of the 14 naïve ones (based on Rosati et al., 2007), it emerged that the expert chimpanzees opted for the delayed reward significantly less than the naïve chimpanzees did ($\%Delay_{exp} = 43.2 \pm 8.90$, $\%Delay_{naïve} = 74.9 \pm 3.70$, Mann–Whitney U test: $U = 5.50$, $n_{exp} = 5$, $n_{naïve} = 14$; $p = .004$). This might indicate that the naïve chimpanzees, as opposed to expert ones, selected the larger delayed option mostly because it was the more prepotent one, without necessarily being aware of the associated delay (although age differences between the two chimpanzee groups might have also affected their behavior).

In conclusion, in view of the limited evidence of a correlation between the ITC task and the accumulation task reported in the present study and, likewise, of a moderate convergence across different self-control measures reported for adult humans (Duckworth & Kern, 2011), correlational studies like the present one should be extended to other species, populations of the same species, and other types of delay of gratification tasks. It would be especially interesting to investigate how chimpanzees, the only species that so far has shown a good performance in both tasks when different populations were compared, would perform when tested in the two tasks with a within-subject design. A better understanding of what each task exactly measures is necessary to foster our knowledge of the origins and mechanisms of delay of gratification.

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