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Self-control assessments of capuchin monkeys with the rotating tray task and the accumulation task

Michael J. Beran[a,*], Bonnie M. Perdue[b], Mattea S. Rossettie[c], Brielle T. James[a], Will Whitham[a], Bradlyn Walker[a], Sara E. Futch[d], Audrey E. Parrish[a]

[a] Department of Psychology and Language Research Center, Georgia State University, United States
[b] Department of Psychology, Agnes Scott College, United States
[c] Language Research Center, Georgia State University, United States
[d] Department of Psychology, Wofford College, United States

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ABSTRACT

Recent studies of delay of gratification in capuchin monkeys using a rotating tray (RT) task have shown improved self-control performance in these animals in comparison to the accumulation (AC) task. In this study, we investigated whether this improvement resulted from the difference in methods between the rotating tray task and previous tests, or whether it was the result of greater overall experience with delay of gratification tasks. Experiment 1 produced similar performance levels by capuchins monkeys in the RT and AC tasks when identical reward and temporal parameters were used. Experiment 2 demonstrated a similar result using reward amounts that were more similar to previous AC experiments with these monkeys. In Experiment 3, monkeys performed multiple versions of the AC task with varied reward and temporal parameters. Their self-control behavior was found to be dependent on the overall delay to reward consumption, rather than the overall reward amount ultimately consumed. These findings indicate that these capuchin monkeys' self-control capacities were more likely to have improved across studies because of the greater experience they had with delay of gratification tasks. Experiment 4 and Experiment 5 tested new, task-naïve monkeys on both tasks, finding more limited evidence of self-control, and no evidence that one task was more beneficial than the other in promoting self-control. The results of this study suggest that future testing of this kind should focus on temporal parameters and reward magnitude parameters to establish accurate measures of delay of gratification capacity and development in this species and perhaps others.

1. Introduction

Sometimes waiting leads to better rewards than simply taking what one can have more immediately. The initial choice between waiting for later or acting now (called inter-temporal choice) and the ability to maintain that choice through a delay to a better reward (delay of gratification) are two aspects of what is called self-control. Without question, the ability to wait, and thus show greater self-control, can produce clear advantages in a number of circumstances ranging from dietary habits to financial wellbeing (e.g., Baumeister et al., 1994; Logue, 1988; Mischel, 2014). Studies that assessed children's self-control and then re-examined those children's lives years or decades later showed that better self-control exhibited when young predicted better objective outcomes much later in life (e.g., academic and social competence, Mischel, et al., 1988; physical health, economic, and criminality outcomes, Moffitt et al., 2011; coping ability, Shoda et al., 1990; mental health, Tangney et al., 2004).

Within the comparative literature, a number of tests have been designed to assess self-control. Some, like the inter-temporal choice task, require animals to make dichotomous smaller-sooner (or lesser-sooner) versus larger-later (or better-later) choices. In that case, choice of the larger-later option means animals are then committed to waiting out the delay interval (e.g., Ainslie, 1974; Berns et al., 2007; Logue, 1988; Tobin et al., 1993, 1996; Rachlin and Green, 1972; Stevens et al., 2005a; Stevens and Mühlhoff, 2012). Other tasks require animals to avoid immediate rewards for the sake of obtaining later, better ones, either through movements through space where the less preferred item is encountered first (e.g., Evans and Westergaard, 2006; Stevens et al., 2005b) or by

* Corresponding author.
E-mail address: mjberan@yahoo.com (M.J. Beran).

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keeping a lower preference item (rather than consuming it) through a delay in order to exchange it for a more preferred item at a later time (e.g., Beran et al., 2016; Dufour et al., 2007; Judge and Essler, 2013; Pelé et al., 2010, 2011; Ramseyer et al., 2006). In these tasks, subjects must avoid taking the less preferred but more immediate reward, which is always present and (presumably) always a temptation, so as to later obtain the better reward (e.g., Beran et al., 1999; Grosch and Neuringer, 1981).

In some cases, the immediate reward may even increase in value over time, but only so long as the animal refrains from consuming the reward(s), thus demonstrating delay maintenance. This test, called the accumulation task, was first used with human children (e.g., Toner and Smith, 1977) and was later adapted for use with nonhuman animals (Beran, 2002). Some species are quite successful with this task, particularly the great apes (Beran, 2002; Beran and Evans, 2006; Evans and Beran, 2007a; Parrish et al., 2014; Stevens et al., 2011). Other species such as monkeys (e.g., Anderson et al., 2010; Evans and Beran, 2007b) and African Grey Parrots (Vick et al., 2010; but see Koepke et al., 2015) do not maintain the same degree of delay maintenance that is shown by apes in the accumulation task.

One species that has been studied fairly extensively with self-control tests is the capuchin monkey. These monkeys are well known for their manipulation skills, and for showing some cognitive abilities that rival those seen in Old World monkeys and in great apes (quantity discrimination, Beran, 2008; representing serial order, D'Amato and Colombo, 1988; tool discrimination, Evans and Westergaard, 2004; numerical competence, Judge et al., 2005; classification, McGonigle et al., 2003; same/different classification, Wright and Katz, 2006). However, capuchin monkeys typically failed to show good self-control, including in the accumulation test, and even with extensive experience (Addessi et al., 2013; Evans et al., 2012; Paglieri et al., 2013). Thus, the capuchin monkey provides a good model for attempting to facilitate better self-control through manipulation of experience and task parameters that might help generate longer delay of gratification.

We recently designed a task that might be more intuitive and easier for these monkeys to engage with, the rotating tray task (Bramlett et al., 2012). Capuchin monkeys successfully exhibited self-control in this test. One concern in previous assessments was that the prepotency of the visible food item might influence responding. In other words, a visible food item may elicit a prepotent response to take the food, even if doing so means that the larger-later item is never recovered. However, this is not due to a lack of self-control per se, as subjects may not have understood the nature of the task and simply responded to prepotent cues. Similarly, when presented with a smaller and larger item simultaneously, subjects might take the larger item without understanding that it is related to a longer delay (see Paglieri et al., 2013). To overcome these issues, we began by presenting monkeys with two food items that were at different spatial locations, but still simultaneously visible. One food item was nearer, and would move within reach more immediately, whereas the second started further away, but could be visually tracked throughout the trial as it moved closer to the monkey. In this way, the rotating tray task removed some of the prepotency issue as both options started at a distance rather than immediately within reach of the monkey and it removed the uncertainty about future availability of each food reward as both were visible and clearly part of the apparatus that the monkey could engage. At the same time, the rotating tray task, like the accumulation task, did require inhibition of reaching-and-taking responses because on trials in which self-control was required, the monkey had to allow the lower value reward to pass by in order to receive the more valuable reward. However, it also differed from the accumulation task in that after an item moved past a monkey, it again went out of reach. This allowed the monkey to attend more to the next item that approached, whereas the accumulation task always kept accumulated food items within reach of the subject, potentially requiring greater levels of sustained self-control in face of a growing reward set.

Our initial efforts with qualitatively different foods were successful, as the monkeys allowed a low-preference carrot piece to pass them by in order to obtain a banana slice (the more preferred food; Bramlett et al., 2012). Having demonstrated success with that variation, we then gave them different quantities of the same food type (banana). Some researchers have argued that quantitative reward differences are less likely to promote or sustain delay of gratification than qualitative differences (e.g., Hillemann et al., 2014), but in this case, many of the monkeys we tested also proved successful in waiting for the larger piece of food. In a follow-up study, we presented new conditions in which the food items were first shown to the monkeys and then placed into opaque containers rather than being visible throughout the trial (Perdue et al., 2015).

After these initial efforts to train and test capuchin monkeys with the rotating tray task, it was clear that these monkeys had become more proficient on that task than the accumulation task (e.g., Evans et al., 2012), but there was an order effect to consider, given that they were exposed to the rotating tray task after their experiences with the accumulation task. Thus, our first question in the present study was whether experience with the rotating tray task might have led to a generalized increase in self-control that would manifest in better performance with the accumulation task. In essence, we were interested in whether the monkeys might have become more self-controlled simply due to more experience in having to wait to get better rewards across different paradigms. To assess this in Experiment 1 and Experiment 2, we gave capuchin monkeys alternating sessions of each delay of gratification test, and then examined which of the two tests led to objectively better self-control. To do this, we carefully controlled the temporal parameters of both tests, and also the payouts for delay of gratification in both tests. We predicted that, although performance on the rotating tray task would exceed performance in the accumulation test, the monkeys might still show better performance in the accumulation task than they had shown in previous studies (Evans et al., 2012). Subsequent experiments assessed the extent to which performance had improved in these animals on the accumulation test and assessed their general levels of self-control compared to previous experiences. We also tested new, task-naïve monkeys with no experience on either self-control task to determine the relation of performance in these two tasks, and whether training and experience with one might scaffold performance on the other. Such results, if evident, could provide insights for interventions that would work to improve self-control in at-risk individuals or low self-control species.

2. Experiment 1

This experiment assessed whether capuchin monkeys were better at accumulating rewards when they could watch the reward progressing towards (and then past) them using the rotating tray task than in the accumulation task that involved rewards continuously being placed into an immediately-accessible food tray. We compared performance levels in terms of the number of items obtained with each task. We predicted, given past results with these animals, that the rotating tray task would produce better performance than the accumulation task because the maintenance of inhibition in the rotating tray task is required only while the reward passes by, and because attention can be focused elsewhere at this time (on the delayed, distant and better reward). The two tasks were otherwise identical in the sense that the accumula-