

Journal of Comparative Psychology

Delayed Gratification: A Grey Parrot (*Psittacus erithacus*) Will Wait for a Better Reward

Adrienne E. Koepke, Suzanne L. Gray, and Irene M. Pepperberg

Online First Publication, July 27, 2015. <http://dx.doi.org/10.1037/a0039553>

CITATION

Koepke, A. E., Gray, S. L., & Pepperberg, I. M. (2015, July 27). Delayed Gratification: A Grey Parrot (*Psittacus erithacus*) Will Wait for a Better Reward. *Journal of Comparative Psychology*. Advance online publication. <http://dx.doi.org/10.1037/a0039553>

Delayed Gratification: A Grey Parrot (*Psittacus erithacus*) Will Wait for a Better Reward

Adrienne E. Koepke
Hunter College, City University of New York

Suzanne L. Gray and Irene M. Pepperberg
Harvard University

Delay of gratification, the ability to forgo an immediate reward to gain either better quality or quantity, has been used as a metric for temporal discounting, self-control, and the ability to plan for the future in both humans (particularly children) and nonhumans. The task involved can be parsed in several ways, such that the subjects can be required to wait, not only for a better or a larger reward, but also such that the rewards can either be in view or hidden during the delay interval. We have demonstrated that a Grey parrot (*Psittacus erithacus*) trained in the use of English speech could respond to the label “wait” for up to 15 min, in a task that has many similarities to those used with young children, to receive a better quality reward, whether or not the better quality reward or the experimenter was in view.

Keywords: Grey parrot, delay of gratification, avian cognition, impulse control, temporal discounting

Supplemental materials: <http://dx.doi.org/10.1037/a0039553.supp>

Delay of gratification involves postponing immediate available rewards to gain more desirable future rewards, maintaining the choice to delay, and tolerating the frustration of this self-inflicted delay (Mischel, Shoda, & Rodriguez, 1989). In mammals, such self-control is an executive function associated with specific cortical areas and their interactions (Figner et al., 2010; Hare, Camerer, & Rangel, 2009; Miyake et al., 2000; Peters & Büchel, 2011). One might therefore expect nonhuman species with larger relative

cortical and analogous cortical-like areas (e.g., apes, parrots, corvids; see Güntürkün, 2005; Kalenscher, 2005; Kalenscher et al., 2005; Iwaniuk, Dean, & Nelson, 2005) to be most likely to succeed in delayed-gratification tasks. Nevertheless, some form of delayed gratification might also be expected to be of value for almost all species. That is, species might favor choices involving long-term, advantageous return instead of immediate, lesser gain for planning goal-directed behavior and future-oriented decisions in foraging and mating (Kacelnik, 2003; Stephens & Krebs, 1986; Stevens & Stephens, 2010; Wascher, Dufour, & Bugnyar, 2012).

Delay of gratification, however, is less common and more complex than might at first appear. In laboratory tests, some nonhumans wait only a few seconds for higher value rewards (reviewed in Hillemann, Bugnyar, Kotrschal, & Wascher, 2014). Evolution-based trade-offs might thus exist between impulsivity and self-control, involving flexibility in resource exploitation and competition (Murray, Kralik, & Wise, 2005). For example, immediacy might be most adaptive if delaying food intake increased risk for survival (see, e.g., Kalenscher & Pennartz, 2008; Stephens, 2008). Whether the future reward is better in quality or quantity may also affect results (e.g., Bateson, 2002): Foragers might pass over an acceptable food source en route to one of better quality, but stopping for a small quantity en route to a larger, equal quality source likely poses few risks. In some species, foraging impulsively is adaptive in the long run (e.g., Stephens, Kerr, & Fernández-Juricic, 2004). Such a strategy relates to temporal discounting—that is, the longer the delay, the lower the perceived reward value (see Stevens & Stephens, 2010). Finally, subjects, particularly in studies involving experimenter-enforced delays, might respond based on the reliability of the situation: whether they trust that the experimenter will indeed make good on the promise of the higher value reward (observed with children; Kidd, Palmeri, & Aslin, 2013). Therefore, multiple competing strategies may determine if gratification may be delayed, and the specific

Adrienne E. Koepke, Department of Psychology, Hunter College, City University of New York; Suzanne L. Gray and Irene M. Pepperberg, Department of Psychology, Harvard University.

This research was supported by donors to The Alex Foundation (particularly Alex and Michael Shuman and the Marc Haas Foundation, the Anders Sterner family, Anita Keefe, Janice Boyd, Nancy Chambers, Kathryn and Walter McAdams, Nancy Sondow, Joseph Golden, Katie Dolan, Megumi Oka and the Makioka Foundation, The California Community Foundation, The Platinum Parrot [Lisa and George Bono], Elva and Bob Mathiesen, Jan and Jeff Strong, Bill Broach and Nancy Clark, James Armstrong, Deborah Rivel Goodale/Wildtones, The Robert D. Goodale Fund [via the Indian River Community Foundation], Patti DeMar Hauver, Charlene Bebko, Don and Grace Wheeler, Arlene Levin Rowe/Grey Parrot Studios, Pat Hill, Daisy Paradis/The Howard Bayne Fund, Dan Vollmer, the Dutch Parrot Foundation [Stichting Papegaai], Linda Reusmann, Pat Anderson, Su Egen/The Medwick Foundation, Phoenix Landing, Ann Dey, Denise and Gary White, Debbie Johnston, Susanna Riordan, and the South Bay Bird Society). We thank Harrison’s Bird Food, the Lafeber Company, and Gini’s Birdie Bread for food and treats. The study procedures comply with the current laws of the country under which they were performed (United States).

Correspondence concerning this article should be addressed to Irene M. Pepperberg, Department of Psychology, William James Hall, Harvard University, 33 Kirkland Street, Cambridge, MA 02138. E-mail: impepper@fas.harvard.edu or impepper@media.mit.edu

conditions of the laboratory task may affect which strategies are exhibited.

Of additional importance is that delayed gratification consists of two independent but related components, originally tested together in children (Mischel, 1974). The first, *delay choice*, is the initial election to wait for the better future reward. The second, *delay maintenance*, is the ability to bridge the delay interval; that is, to continuously inhibit the impulse to take the immediate reward during the delay after the initial choice has been made to wait (Mischel et al., 1989; Toner, Lewis, & Gribble, 1979; Toner & Smith, 1977). Mischel's early studies measured children's ability to renounce an immediate, less-preferred reward (one marshmallow) and sustain that decision while waiting for a preferred outcome (two marshmallows).

For nonhumans, choice and maintenance are often tested independently (e.g., Addessi et al., 2013) and this division may affect outcomes (e.g., Paglieri et al., 2013). In delayed-reward contingency tasks, also known as intertemporal choice tasks or self-controlled tasks, subjects choose between an immediate, lower value food or delayed, higher value food. Results may be confounded, however, because subjects are often unable to inhibit pointing to the better payoff (see Hillemann et al., 2014), and then cannot change their decision during the experimenter-specified delay. This task, therefore, does not test if a subject can sustain a delay choice. During delay-maintenance tasks, in contrast, subjects can alter their initial choice at any time. Tasks commonly use an exchange or accumulation paradigm. In the former, which involves waiting for *better*, subjects are given an immediate, less preferred food they can keep intact throughout the delay and then exchange for something of greater value, or end the trial by consumption. In the latter, waiting for *more*, a series of identical edibles is moved within reach of the subject at a fixed rate (usually seconds) per item. The food accumulates until the subject interrupts by taking the available rewards.

Waiting for better versus waiting for more can also affect results. Avian and nonhuman primate species performed comparably when the reward to be exchanged differed in quality, even though primates may have had an advantage: The primates could hold food in their hands, whereas birds often must hold the initial food item in their beaks, close to their taste organs. For nonhuman primates (e.g., chimpanzees, *Pan troglodytes*; long-tailed macaques, *Macaca fascicularis*; capuchin monkeys, *Cebus capucinus*), corvids (e.g., carrion crows, *Corvus corone*; common ravens, *Corvus corax*), and Goffin cockatoos (*Cacatua goffini*), waiting times varying from a few seconds to several minutes (reviewed in Hillemann et al., 2014). One corvid subject waited for 640 s; cockatoos' longest waiting time was 80 s. In contrast, nonhuman primates outperformed birds in quantity tasks. One chimpanzee (*Pan troglodyte*) waited for ~180 s in an accumulation task without training and ~640 s after having delays gradually extended (Beran & Evans, 2006). Despite having the cognitive capacity to discriminate different quantities of food and choose higher quantities in a binary preference test, most corvids and cockatoos could not delay beyond ~20 s, although one female raven waited 320 s (Hillemann et al., 2014). When tested for delay maintenance in an accumulation task, only one of three Grey parrots (*Psittacus erithacus*) could wait 2–3 s for access to seeds; these birds' ability to delay gratification in the context of quality was not tested (Vick, Bovet, & Anderson, 2010). The significantly

different outcomes between nonhuman primate and avian subjects may be a consequence of different evolutionary pressures (reviewed in Hillemann et al., 2014); however, only a limited number of avian species have been tested on the different tasks.

Visibility of reward also may affect a subject's ability to delay gratification (Mischel et al., 1989). Children (3–5 years old) waited on average over 11 min when the reward was not visible, but less than 6 min for visible rewards (Mischel & Ebbensen, 1970; Mischel et al., 1989). Effect of reward visibility has been tested in a few other species. Pigeons also waited longer when the preferred rewards were not visible (Grosch & Neuringer, 1981). In contrast, neither Grey parrots (Vick et al., 2010) nor chimpanzees (Beran & Evans, 2006) showed significant change in delay maintenance when proximity and visibility of rewards were manipulated in an accumulation task. However, visibility was not tested with foods of differing quality.

After examining these earlier studies, we chose to test a Grey parrot in a quality delay maintenance task markedly similar to that used with young children (Mischel et al., 1989): Could a parrot, trained in the use of English speech, including the vocal label "wait," inhibit the impulse to consume an immediately available, preferred food item to receive an even more preferred item? We examined effects of reward visibility in conjunction with experimenter presence on delay time, the first time this issue was tested in birds in an exchange task. We reduced reward inequality by using two highly desirable rewards that were preferred over daily dietary offerings. To test whether exchange paradigms might require less self-control for species that hold food in their hands rather than their mouths, the parrot was given the initial food item within reach on a tray rather than being required to hold it in his beak. The present study incorporated delay times up to 15 min in both not-visible and visible conditions; success on not-visible trials might indicate the capacity for mental representation of the most preferred reward (Mischel et al., 1989).

Method

Subject

A male Grey parrot (*Psittacus erithacus*), Griffin, was tested in a Harvard laboratory. He has been a subject of continuing studies on comparative cognition and interspecies communication (e.g., Pepperberg & Hartsfield, 2014; Pepperberg & Shive, 2001; Pepperberg & Wilcox, 2000; Pepperberg et al., 2013). He could vocally identify foods, toys, colors, and shapes, and understood vocal labels such as "climb" and "wait" in the context of his daily routine (e.g., to "wait" until hot food cooled). He was 18 years old at the start of the experiment; he had been in the lab since he was 7.5 weeks old. Housing and general feeding conditions have been described in Pepperberg and Wilkes (2004); conditions were maintained after moving to Harvard in July, 2013. Griffin was never food- or water-deprived, but desirable treats used in the experiment were withheld for at least several hours before testing.

Introduction of the Task

Griffin needed to comprehend the basic task before its initiation. He already had experienced the instruction "wait" within his daily routine; that is, to be told he had to wait before he could have

something he wanted, but the label was never used within the context of an *alternative* choice. We thus needed to introduce the concept of alternative rewards without engaging him in extensive training on the exchange task itself. We were also not trying to determine his comprehension of the label “wait,” nor was the point of the study to see if he would spontaneously transfer it to the context of this task. Rather, our goal was to test his capacity to delay gratification. Consequently, we briefly demonstrated the novel existence of an alternative for which he could wait: The experimenter put a Harrison’s pellet (food that is part of his regular diet, always available, but not particularly preferred) and a nut (a favored treat) on a tray in front of Griffin and placed a finger over each of the treats. She slid the pellet forward, said “wait,” removed her hand from the pellet, keeping her finger on the nut. She waited less than 5 s, then gave Griffin the nut if he did not eat the pellet. He could not access the nut during the wait, but observed that “wait” was associated with an alternative choice. We also used a dried berry (a lower-tiered favorite treat) and a nut, again with a <5-s delay, to show him that this concept of waiting for an alternative existed for more than one food pairing.

Before actual experimental trials began, Griffin received 17 additional trials in which we examined variations of the finalized protocol to ascertain the best conditions in which to test his ability to delay gratification. Such variations included determining the method for presenting rewards (e.g., use of metal cups), confirming the relative desirability of the rewards, and testing the effect of the experimenter turning her back to Griffin in addition to backing away from him. Griffin waited in all but three of these trials (plus one mistrial when he chose to eat neither treat). Learning that Griffin’s behavior did not alter when, for example, we used metal cups instead of placing treats directly on the tray allowed for a methodology we could eventually also use in testing delay in quantitative situations. Having the experimenter turn her back to Griffin allowed a third condition: for her to be visible while the treat was not visible. We decided, however, to have only two conditions: preferred reward and experimenter both visible or both not visible. All pretrials involved randomized delays of between 5 s and 5 min so that Griffin was never trained to wait for increasingly long delays (seven trials were <1 min, one trial was 80 s, four trials were 2 min; five trials used delays of 5 min).

Finalized Apparatus and Procedure

Rewards consisted of pairs constructed from seven highly preferred food items: Heritage cereal flakes, dried berries, cashew nuts, almonds, crackers, Nestle Nerds candy, and Mars Skittles candy. Three tiers of desirability existed within the parrot’s food-preference hierarchy: (a) most desirable were the candies; (b) next were cashews, almonds, and crackers; (c) least (although still preferred to his regular diet) were dried berries and cereal flakes. This hierarchy was stable over time. However, Griffin’s preferred food type within each tier could vary from day to day and trial to trial. To determine what he preferred on a test day, he was, on most trials (see below) given one food type from each of two different tiers for consumption; however, we never pitted the most favored (candies) with the less favored (berries, cereal), so he would always be tested with items that were close in desirability. To test our assumptions about desirability, in four trials we did use two food items from the second tier. On a given day, we used a pair if he showed interest in both potential test items. We noted what he consumed first to further confirm that it was most preferred overall. Then, after a delay of at least 15 min (to ensure he was not satiated and would still want treats), at the start of each individual trial, Griffin was offered these two food types a second time, but now was not allowed to consume them. Whichever treat he approached first was confirmed as the most favored for that trial.

At the beginning of each trial, Griffin was placed on a T-stand in front of a laboratory stool. Two same-sized stainless steel cups, approximately 45 cc, familiar as feeding vessels, were initially placed on the stool equidistant from each other and from his beak (see Figure 1). This arrangement was familiar to him from several earlier experiments (e.g., Pepperberg & Hartsfield, 2014; Pepperberg et al., 2013).

Test Trials

At the start of each trial, the experimenter placed one treat in each hand, showing them to Griffin. She then dropped both treats into the cups within his view, raising the cups and shaking them briefly to ensure he saw what was in each cup. If his attention seemed to wander, the experimenter called him by name, telling him to “Look” or “Pay attention.” She then placed the cup with the

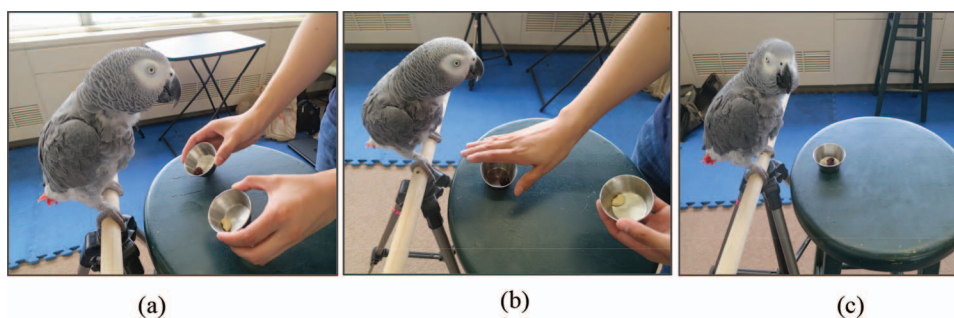


Figure 1. Presentation of stimuli. (a) Experimenter placed one treat in each cup and showed each to Griffin. (b) Experimenter positioned cup with one treat (less-preferred in noncontrol trials; more-preferred in control trials), and briefly covered it with her hand as she said, “Wait.” (c) For each trial/condition, experimenter either stood several feet away, showing treat (visible condition) or left room with treat (not-visible condition). See the online article for the color version of this figure.

less preferred treat on the stool within his reach, briefly covered it with her hand as she said “wait” and then, for the designated delay, either stood several feet away, showing him the treat (visible condition) or left the room with the treat (not-visible condition). In the visible condition, she balanced the cup containing the treat against her leg so it faced the direction in which Griffin was initially looking, but was careful not to gaze at the bird, engage him in any way, or track his movement. At the end of the delay time, if Griffin had waited, she gave him the preferred treat and removed the less-preferred item. She never ended the trial until the entire delay time had expired, so Griffin could not instigate her return (another possible reward) simply by eating whatever was in front of him.

We conducted 10 trials for each delay time (10 s, 40 s, 160 s, 320 s, 640 s and 900 s), in each of the two conditions. One control trial for each delay time, in each condition, was interspersed among test trials. Control trials were identical to test trials except that Griffin received the more preferred treat first and could wait for the less preferred treat. Trials conducted on the same day (generally over a 4–5-hr period) were separated by at least 15 min and generally only four trials were conducted over the course of a single day to avoid massing trials and preventing the bird from becoming satiated and uninterested in the experiment. However, if Griffin was eager to work (as determined, e.g., by vocal requests for additional treats—“Want nut!”), we might perform five to seven trials in a given day but trials were still separated by at least 15 min. In all cases, he was placed back on his cage between trials to designate intertrial intervals clearly. Delay times, left/right placement of the treat, and whether the experimenter and treat were visible, were all randomized using the program Random.org.

A Go-Pro® camera was placed so as to record all control trials and at least half of all test trials (a minimum of two trials for each delay in each condition). Trials were scored in real time and then 48 videos selected to represent different time delays were independently scored by one of two naïve observers (students not involved in this study) for interobserver reliability.

Results

Griffin waited for the preferred reward at all delay times. Overall, for all delays on visible and not-visible conditions, he successfully waited on 108/120 (90%) of the trials (binomial test, $p < .001$). Results are illustrated in Figure 2. He succeeded in the not-visible condition on 55/60 (91.7%) of the trials (binomial test, $p < .001$). In the visible condition, he successfully waited on 53/60 (88.3%) of the trials (binomial test, $p < .001$). In 12/12 (100%) of the control trials, one in each of the different delay times and conditions, Griffin elected to eat the initial, preferred reward rather than wait for the less preferred reward, therefore demonstrating his attention to reward type and his recognition of “wait” as a label for an action rather than a command. Notably, in 10/12 of the control trials, he ate the initial reward within 1–2 s; in the other two trials, he did wait somewhat longer, but these trials pitted candies against nuts (items from two different tiers, but still very close in desirability; see below) and they were the first two controls—the first times he was given the most preferred item initially, which may have come as a surprise. Naïve raters of the videos agreed 100% with the experimenters on the actions in which Griffin engaged during trials.

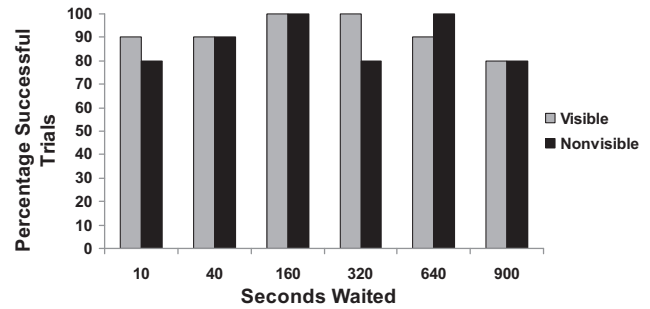


Figure 2. The percentages of trials at each time delay for which Griffin waited or failed to wait. Black bars represent trials in which the most favored reward was visibly present; gray bars represent trials in which that reward was not visible.

To ascertain effects of visibility and delay time on the likelihood that Griffin would wait, we performed a logistical regression. A logistical regression allows determination of: 1) whether predictors as a whole significantly affect the outcome variable (addressed by the model chi-square statistic) and 2) the individual effect of each predictor in the context of other predictors on the outcome variable (addressed by a Wald statistic). A test of the overall model was not statistically significant, indicating that delay time and visibility combined did not predict successful waiting, $\chi^2(2) = .499$, $p = .779$. The Wald criterion further demonstrated that individually, neither delay time, Wald $\chi^2(1) = .127$, $p = .721$, nor visibility, Wald $\chi^2(1) = .368$, $p = .544$, affected successful waiting.

Inquiry into Griffin’s failed trials clarifies the findings. His 12 failures numbered roughly the same in visible and not-visible conditions. The majority of failures (9/12 or 75%) occurred in the shortest and longest delays (10s, 40s, 900s). When he failed to wait, he almost always (in 10/12 failures) decided to take the available reward within a few (≤ 5) s, even though (due to randomization of delay intervals) he could not predict delay duration. Twice, however, he failed after waiting for nearly the complete time delay: In Trial 51 (visible condition), he ate the available food after 815s (95%) of a 900s delay; in Trial 96 (not-visible condition), he failed to wait after 740s (80%) of a 900s delay. That is, he seemed either actively to choose the less-favored reward (10/120 trials) or to wait the whole time; he “gave up” after trying to delay only twice.

Griffin did not show a learning curve. Again, because delay times were randomized throughout, he could not predict if a delay interval would be short or long; therefore, he was not trained to wait for a progression of longer and longer delays. He did make most of his errors (10/12) in the first half of the 120 trials (see Figure 3), but the distribution within those first 60 trials was random. Thus, although a linear regression over the entire set of trials showed a significant correlation between trial number and error distribution, $F(1, 117) = 5.91$, $R^2 = 0.05$, $p = .02$, a linear regression over the first half of trials showed that the correlation was nonsignificant, $F(1, 57) = 1.106$, $R^2 = 0.02$, $p = .30$.

Of particular interest were what appeared to be coping strategies for dealing with the delays, many of which were reminiscent of those used by children in the early Mischel and Ebbsen (1970) task. For Griffin, long delays were often accompanied by behavior patterns such as preening, sleeping, vocalizing and manipulation of

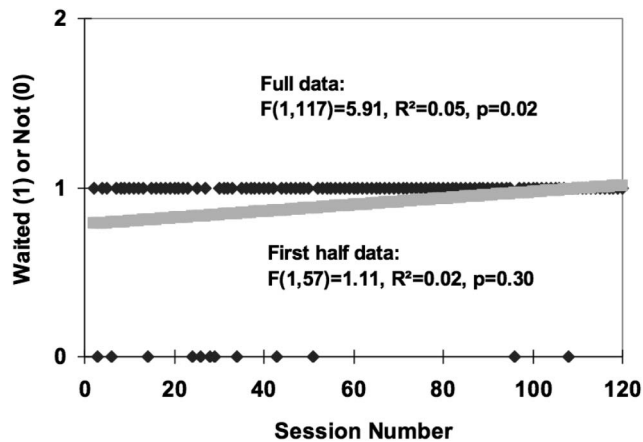


Figure 3. Linear regression (gray line) of the data (black points) showing the variation in time of successful and unsuccessful trials. The regression is significant over the course of the entire experiment because most errors were made in the first half of the trials. Over the first half of trials, however, the regression is not significant, showing that Griffin's pattern of errors was random and that he actually did not learn to wait during the course of the experiment.

the available reward. When observed in children, these behavior patterns are often termed “self-distractive” (see Appendix, supplementary video).

Reward type or pairing did not affect success or failure, except for reward pairs very close in desirability. No statistical differences existed for success versus failure across tiers (Fisher's exact test, $p = .45$). On his two failures after waiting almost 900s, the pairing was candy (Nerd or Skittle) and a cashew—different tiers, but close in preference and highly preferred overall. With only two such trials, however, little can be deduced from his actions. As noted above, we rarely contrasted food in the same tier, specifically so that Griffin would prefer the delayed item. In four trials that did use such closely desirable rewards (to test this premise), he failed to wait on two trials (40 s, 320 s), deciding to eat the physically present item almost immediately.

Discussion

Griffin, a Grey parrot, could wait for a better quality reward for up to 15 min, even though both items were preferred foods. He delayed gratification for longer than any previously tested avian subject (e.g., Goffin cockatoos: Auersperg et al., 2013; corvids: Dufour et al., 2012; Hillemann et al., 2014), whether the most preferred food or the experimenter was visible or not. Note that 15 min was the longest time we tested, not necessarily the longest he would wait. We discuss specific reasons that might have led to his success, as well as alternative explanations for his behavior.

Experimental Design

Our paradigm differed somewhat from those used with other avian subjects, possibly increasing or decreasing task difficulty. Specifically, Griffin did not have to keep food in his beak, he was not tested on progressively longer delays, he already had some understanding of “wait,” the better reward could be visible or out

of sight, both immediate and delayed rewards were desirable, and his lack of waiting was not a consequence of satiation.

Some avian subjects (e.g., Goffin cockatoos, Auersperg et al., 2013) had to hold the less preferred treat in their beaks while waiting. This food, however, was still a desirable item that could be tasted and easily consumed. Other subjects (e.g., corvids, Dufour et al., 2012; Hillemann et al., 2014) although not required retain the food in their beaks, had to take the food orally in the exchange paradigm. Griffin, in contrast, sat with the treat in a proximate small cup, much like primates who also waited for long delays (e.g., Dufour et al., 2007). Not being tempted by taste might have enabled him to delay for longer periods. Also, having a treat in a cup, not in his beak, might have prevented him from accidentally ending the task; conceivably, a bird could physically tire of keeping an item in its beak without actually desiring to abort a trial to acquire the more desirable food. Such might have been an issue with the Goffin cockatoos (Auersperg et al., 2013).

Unlike previously tested avian subjects (Auersperg et al., 2013; Dufour et al., 2012; Hillemann et al., 2014), Griffin was not subjected to longer delays as the experiment progressed; he had no idea how long a given trial might take. Thus he could not have been trained to wait for progressively longer periods. Rather, he had to choose to wait as long as necessary; in general, he decided either not to wait at all (10/12 failures), or to endure the entire delay. Except for two trials, at the longest delay, 15 min, if he decided to wait he succeeded. He seemed to recognize the concept of delayed gratification, even at the onset of the experiment. Notably, he erred only twice in the first 10 trials (see Figure 3), and within those 10 trials, succeeded on the first very long delay, 640 s. (By chance, the longest delay, 900 s, did not occur until the 13th trial, on which he also succeeded.) Such randomized delays are more ecologically valid; in the wild, different food items are likely separated by different distances/times to acquisition based on the daily randomness of, for example, ripening patterns of fruits.

Griffin entered the experiment with some rudimentary knowledge of the vocal label “wait,” which may have made his task somewhat easier. Each noon he is given highly preferred cooked grains, initially too hot to eat. He exhibits considerable anticipatory behavior (e.g., beak gaping, wing fluttering) at the microwave ping that indicates that the grains will soon be available. Each day he is told to wait, although hearing the label does not decrease his anticipatory actions. He evinces similar behavior at the principal investigator's entry into the lab, expecting to be picked up and preened; he also always hears “wait” while she uses hand sanitizer and removes her outdoor shoes. Again, the instruction has little effect on his behavior, but he may have already associated the vocalization with delay of something he desires. What is important is that he did not interpret “wait” as a command. As noted above, when given the most preferred item first in controls, he ignored the word on all 12 control trials. Thus he appeared to evaluate the situation and decide whether or not to follow our instruction.

Griffin's understanding of “wait” also meant that, unlike most other nonhumans, avian or primate (e.g., Auersperg et al., 2013; Dufour et al., 2007, 2012), he did not have to be trained extensively on the exchange paradigm before beginning the experiment. He did not have to learn to exchange a nonfood token or less-preferred food item for something desirable, activities which may have affected responses of other subjects. He did have to be introduced to the idea that “wait” could be associated with an

alternative choice, but the few trials and the delays (~5 s) were unlikely to have trained him to be able to wait for up to 15 min, and he clearly recognized when waiting was not to his advantage. Even trials involved in preference testing and determining other variables did not require waiting longer than 5 min, and such trials were rare (see Method section). Demonstration trials therefore were merely a way to explain the task, as his understanding of English is hardly comparable to that of a 4-year-old child. Thus, despite the fact that we tested for only quality and not quantity of reward, Griffin's behavior could be more closely compared with that of humans (e.g., Mischel et al., 1989) than was possible for other, more extensively trained nonhumans.

Given that reward visibility increased children's difficulty for waiting (Mischel & Ebbesen, 1970; Mischel et al., 1989), we tested Griffin on both visible and not-visible conditions. For both cockatoos (Auersperg et al., 2013) and corvids (Dufour et al., 2012; Hillemann et al., 2014), the more preferred reward was always visible unless cached; caching corvids were more successful (Dufour et al., 2012). Griffin waited almost equally during visible (53) versus not-visible (55) trials. Thus his decision to wait or eat the less preferred item was unaffected by the presence of the preferred treat, even at the longest delays (see Figure 2). This lack of difference suggests that he maintained a mental representation of the preferred food during delays, enabling him to wait for as long as necessary (Mischel et al., 1989).

Finally, some experimenters (e.g., Bramlett, Perdue, Evans, & Beran, 2012; Drapier et al., 2005) have used much less desirable items as the immediate reward. Subjects in these studies might easily have lost interest in the items, the temptation to consume them might have been missing, and the point of delaying gratification would be less relevant. Here, as in studies with other avian subjects cited above, we used items Griffin strongly preferred over his basic diet, but for which he still had a range of preference. We never paired first- and third-tier items, so he would be motivated to wait, but also be tempted by the immediate reward. We also carefully used pairings that, for most trials, were close in desirability but in different tiers; he did appear very aware of the few times we used equally desirable rewards: If items were of the same tier (e.g., 4 trials, cracker, cashew, almond), he was equally likely to immediately decide to eat what was present than to wait. Notably, he waited in 19/22 trials in which we used items in different tiers, but highly desired overall (candy and nut): Two of the only three times he gave up, he waited almost the full 15 min before deciding to eat the item that was present. Here Griffin showed that he waited not because he had simply lost interest in the immediate reward. His successes, moreover, show that, unlike corvids (e.g., Hillemann et al., 2014), successful waiting at longer time periods was not limited to combinations in which the initial item was one of the least preferred foods; that is, the relationship between length of time willing to wait and quality of reward was not as clear as in the corvid studies (Dufour et al., 2012).

Using a range of rewards also prevented Griffin from considering a particular treat as a signal to wait. Had we used only two choices, the mere presence of the more preferred choice could have been such a signal. Using a range of items, however, forced Griffin to evaluate his choice on each and every trial, including the control trials. Thus he had to make a new decision each time he was presented with a set of items, further demonstrating that he understood the metrics of the task.

Griffin's ability to wait was not likely a consequence of satiation. We were careful not to mass trials to avoid exactly that problem. Rewards were small (e.g., a half or less of a cashew), few trials were performed on any given day, and more than four trials per day occurred only when Griffin gave evidence of desiring more rewards (e.g., vocally requesting a high-tier treat).

Coping Mechanisms

Both nonhumans and humans engage in various behavior patterns to assist in waiting during the delays. Corvids that were successful on the longer delays (>40 s) would cache the less desirable reward in nearby crevices or at least place it down, out of the beak and taste sense (Hillemann et al., 2014). Children were particularly innovative (Mischel & Ebbesen, 1970, p. 335).

They devised elaborate self-distraction techniques. . . . Instead of focusing prolonged attention on the objects for which they were waiting, they avoided looking at them. Some children covered their eyes with their hands, rested their heads on their arms, and found other similar techniques for averting their eyes from the reward objects. . . . They talked to themselves, sang, invented games with their hands and feet, and even tried to fall asleep while waiting . . .

Griffin (see Appendix) performed many similar actions. He could not cover his eyes with his claws, but might throw the cup containing the less favored treat across the room so as not to have it in view; he performed such an action once about a third of the way through a 900-s trial. He would move the cup just out of reach, talk to himself, preen extensively, and, like children, try to fall asleep while waiting (see video). He also, like children in the Steelandt, Thierry, Broihanne, and Dufour (2012) study, occasionally licked the treat, but didn't eat it. Unlike corvids, which are caching species (Dufour et al., 2012), hiding the immediate reward was not part of his repertoire. He engaged in what might be considered classical "displacement" behavior, defined initially for nonhumans (Kortlandt, 1940; Tinbergen, 1940) as occurring when the experience of high motivation for two (or more) conflicting actions causes the subject to exhibit a third action, unrelated to the others, that generally involves something self-directed, like grooming. Humans, however, have also been observed to engage in a third, unrelated behavior as a reaction to the anxiety between choice of action (Maestriperi, Schino, Aureli, & Troisi, 1992). Displacement would thus equally fit the description of both Griffin's and children's actions, and distinguishing intentional distraction behavior from displacement is beyond the scope of the present experiment.

We speculate that Griffin may have engaged in such behavior patterns more rapidly and more frequently as the experiment progressed, as though he had learned to use such actions rather than having them be an automatic response. Because not all sessions were videotaped, we can only note that such behavior seemed likely. Given that he could not predict the length of the delay, his self-distractive behavior patterns suggest that once he decided to wait—generally within the first few seconds of a trial—he had figured out which coping mechanisms were most effective for carrying out that choice.

Furthermore, as noted above, Griffin was not simply losing interest in the immediate reward. On two trials of relatively long durations (900 s each), he waited 80% and 95% of the time before

he gave up and ate the immediate reward. Such behavior suggested that he was very much aware of, and tempted by, that item.

Conclusion

A Grey parrot, Griffin, can wait for a preferred reward for up to 15 min, behavior comparable to, and for a delay longer than, any nonhuman previously tested. Once he decided to delay choice, he likely succeeded on delay maintenance. Thus, at least in a quality exchange paradigm, little difference exists among various avian species and primates. As noted earlier, the ecological relevance of a qualitative delay task is clear: Except in times of severe paucity, foraging for a somewhat longer time to acquire a better food source likely results in better nutritional reward, whatever the species, and involves little cost. Whether the cognitive mechanisms underlying such behavior patterns are based on convergent evolution or analogous brain structures, parrots, corvids, and primates respond similarly. To argue for behavioral similarity in delay across parrots and primates, however, we would have to test if Griffin might, unlike the corvids (Hillemann et al., 2014), Goffin cockatoos (Auersperg et al., 2013), or previously studied Grey parrots (Vick et al., 2010), succeed in a quantitative rather than qualitative differential.

References

- Addressi, E., Paglieri, F., Beran, M. J., Evans, T. A., Macchitella, L., De Petrillo, F., & Focaroli, V. (2013). Delay choice versus delay maintenance: Different measures of delayed gratification in capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *127*, 392–398.
- Auersperg, A. M. I., Laumer, I. B., & Bugnyar, T. (2013). Goffin cockatoos wait for qualitative and quantitative gains but prefer 'better' to 'more'. *The Royal Society: Biology Letters*, *9*, Article 20121092. Advance online publication. <http://dx.doi.org/10.1098/rsbl.2012.1092>
- Bateson, M. (2002). Recent advances in our understanding of risk-sensitive foraging preferences. *The Proceedings of the Nutrition Society*, *61*, 509–516. <http://dx.doi.org/10.1079/PNS2002181>
- Beran, M. J., & Evans, T. A. (2006). Maintenance of delay of gratification by four chimpanzees (*Pan troglodytes*): The effects of delayed reward visibility, experimenter presence, and extended delay intervals. *Behavioural Processes*, *73*, 315–324. <http://dx.doi.org/10.1016/j.beproc.2006.07.005>
- Bramlett, J. L., Perdue, B. M., Evans, T. A., & Beran, M. J. (2012). Capuchin monkeys (*Cebus apella*) let lesser rewards pass them by to get better rewards. *Animal Cognition*, *15*, 963–969. <http://dx.doi.org/10.1007/s10071-012-0522-x>
- Drapier, M., Chauvin, C., Dufour, V., Uhlrich, P., & Thierry, B. (2005). Food exchange with humans in brown capuchin monkeys. *Primates*, *46*, 241–248. <http://dx.doi.org/10.1007/s10329-005-0132-1>
- Dufour, V., Pelé, M., Sterck, E. H. M., & Thierry, B. (2007). Chimpanzee (*Pan troglodytes*) anticipation of food return: Coping with waiting time in an exchange task. *Journal of Comparative Psychology*, *121*, 145–155. <http://dx.doi.org/10.1037/0735-7036.121.2.145>
- Dufour, V., Wascher, C. A. F., Braun, A., Miller, R., & Bugnyar, T. (2012). Corvids can decide if a future exchange is worth waiting for. *Biology Letters*, *8*, 201–204. <http://dx.doi.org/10.1098/rsbl.2011.0726>
- Figner, B., Knoch, D., Johnson, E. J., Krosch, A. R., Lisanby, S. H., Fehr, E., & Weber, E. U. (2010). Lateral prefrontal cortex and self-control in intertemporal choice. *Nature Neuroscience*, *13*, 538–539. <http://dx.doi.org/10.1038/nn.2516>
- Grosch, J., & Neuringer, A. (1981). Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior*, *35*, 3–21. <http://dx.doi.org/10.1901/jeab.1981.35-3>
- Güntürkün, O. (2005). The avian 'prefrontal cortex' and cognition. *Current Opinion in Neurobiology*, *15*, 686–693. <http://dx.doi.org/10.1016/j.conb.2005.10.003>
- Hare, T. A., Camerer, C. F., & Rangel, A. (2009). Self-control in decision making involves modulation of the vmPFC valuation system. *Science*, *324*, 646–648. <http://dx.doi.org/10.1126/science.1168450>
- Hillemann, F., Bugnyar, T., Kotrschal, K., & Wascher, C. A. F. (2014). Waiting for better, not for more: Corvids respond to quality in two delay maintenance tasks. *Animal Behaviour*, *90*, 1–10. <http://dx.doi.org/10.1016/j.anbehav.2014.01.007>
- Iwaniuk, A. N., Dean, K. M., & Nelson, J. E. (2005). Interspecific allometry of the brain and brain regions in parrots (Psittaciformes): Comparisons with other birds and primates. *Brain, Behavior and Evolution*, *65*, 40–59. <http://dx.doi.org/10.1159/000081110>
- Kacelnik, A. (2003). The evolution of patience. In G. Loewenstien, D. Read, & R. Baumeister (Eds.), *Time and decision: Economic and psychological perspectives on intertemporal choice* (pp. 115–138). New York, NY: Russell Sage Foundation.
- Kalenscher, T. (2005). *The role of the avian prefrontal cortex (nidopallium caudolaterale) in decision making*. Unpublished doctoral thesis, Ruhr-Universität Bochum, Bochum, Germany.
- Kalenscher, T., & Pennartz, C. M. (2008). Is a bird in the hand worth two in the future? The neuroeconomics of intertemporal decision making. *Progress in Neurobiology*, *84*, 284–315. <http://dx.doi.org/10.1016/j.pneurobio.2007.11.004>
- Kalenscher, T., Windmann, S., Diekamp, B., Rose, J., Güntürkün, O., & Colombo, M. (2005). Single units in the pigeon brain integrate reward amount and time-to-reward in an impulsive choice task. *Current Biology*, *15*, 594–602. <http://dx.doi.org/10.1016/j.cub.2005.02.052>
- Kidd, C., Palmeri, H., & Aslin, R. N. (2013). Rational snacking: Young children's decision making on the marshmallow task is moderated by beliefs about environmental reliability. *Cognition*, *126*, 109–114. <http://dx.doi.org/10.1016/j.cognition.2012.08.004>
- Kortlandt, A. (1940). Wechselwirkung zwischen Instinkten [Interaction between instincts]. *Archives Néerlandaises de Zoologie*, *4*, 443–520. <http://dx.doi.org/10.1163/036551640X00181>
- Maestripietri, D., Schino, G., Aureli, F., & Troisi, A. (1992). A modest proposal: Displacement activities as an indicator of emotions in primates. *Animal Behaviour*, *44*, 967–979. [http://dx.doi.org/10.1016/S0003-3472\(05\)80592-5](http://dx.doi.org/10.1016/S0003-3472(05)80592-5)
- Mischel, W. (1974). Processes in delay of gratification. In L. Berkowitz (Ed.), *Advances in experimental social psychology*, Vol. 7 (pp. 249–292). New York, NY: Academic Press.
- Mischel, W., & Ebbesen, E. B. (1970). Attention in delay of gratification. *Journal of Personality and Social Psychology*, *16*, 329–337. <http://dx.doi.org/10.1037/h0029815>
- Mischel, W., Shoda, Y., & Rodriguez, M. I. (1989). Delay of gratification in children. *Science*, *244*, 933–938. <http://dx.doi.org/10.1126/science.2658056>
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. <http://dx.doi.org/10.1006/cogp.1999.0734>
- Murray, E. A., Kralik, J. D., & Wise, S. P. (2005). Learning to inhibit prepotent responses: Successful performance by rhesus macaques, *Macaca mulatta*, on the reversed-contingency task. *Animal Behaviour*, *69*, 991–998. <http://dx.doi.org/10.1016/j.anbehav.2004.06.034>
- Paglieri, F., Focaroli, V., Bramlett, J., Tierno, V., McIntyre, J. M., Addressi, E., . . . Beran, M. J. (2013). The hybrid delay task: Can capuchin monkeys (*Cebus apella*) sustain a delay after an initial choice to do so? *Behavioural Processes*, *94*, 45–54. <http://dx.doi.org/10.1016/j.beproc.2012.12.002>

- Pepperberg, I. M., & Hartsfield, L. A. (2014). Can Grey parrots (*Psittacus erithacus*) succeed on a “complex” foraging task failed by nonhuman primates (*Pan troglodytes*, *Pongo abelii*, *Sapajus apella*) but solved by wrasse fish (*Labroides dimidiatus*)? *Journal of Comparative Psychology*, *128*, 298–306. <http://dx.doi.org/10.1037/a0036205>
- Pepperberg, I. M., Koepke, A., Livingston, P., Girard, M., & Hartsfield, L. A. (2013). Reasoning by inference: Further studies on exclusion in Grey parrots (*Psittacus erithacus*). *Journal of Comparative Psychology*, *127*, 272–281. <http://dx.doi.org/10.1037/a0031641>
- Pepperberg, I. M., & Shive, H. R. (2001). Simultaneous development of vocal and physical object combinations by a Grey parrot (*Psittacus erithacus*): Bottle caps, lids, and labels. *Journal of Comparative Psychology*, *115*, 376–384. <http://dx.doi.org/10.1037/0735-7036.115.4.376>
- Pepperberg, I. M., & Wilcox, S. E. (2000). Evidence for a form of mutual exclusivity during label acquisition by Grey parrots (*Psittacus erithacus*)? *Journal of Comparative Psychology*, *114*, 219–231. <http://dx.doi.org/10.1037/0735-7036.114.3.219>
- Pepperberg, I. M., & Wilkes, S. R. (2004). Lack of referential vocal learning from LCD video by Grey parrots (*Psittacus erithacus*). *Interaction Studies: Social Behaviour and Communication in Biological and Artificial Systems*, *5*, 75–97. <http://dx.doi.org/10.1075/is.5.1.05pep>
- Peters, J., & Büchel, C. (2011). The neural mechanisms of inter-temporal decision-making: Understanding variability. *Trends in Cognitive Sciences*, *15*, 227–239. <http://dx.doi.org/10.1016/j.tics.2011.03.002>
- Steelandt, S., Thierry, B., Broihanne, M.-H., & Dufour, V. (2012). The ability of children to delay gratification in an exchange task. *Cognition*, *122*, 416–425. <http://dx.doi.org/10.1016/j.cognition.2011.11.009>
- Stephens, D. W. (2008). Decision ecology: Foraging and the ecology of animal decision making. *Cognitive, Affective & Behavioral Neuroscience*, *8*, 475–484. <http://dx.doi.org/10.3758/CABN.8.4.475>
- Stephens, D. W., Kerr, B., & Fernández-Juricic, E. (2004). Impulsiveness without discounting: The ecological rationality hypothesis. *The Royal Society: Proceedings B. Biological Sciences*, *271*, 2459–2465. <http://dx.doi.org/10.1098/rspb.2004.2871>
- Stephens, D. W., & Krebs, J. R. (1986). *Foraging theory*. Princeton, NJ: Princeton University Press.
- Stevens, J. R., & Stephens, D. W. (2010). The adaptive nature of impulsivity. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 361–388). Washington, DC: American Psychological Association. <http://dx.doi.org/10.1037/12069-013>
- Tinbergen, N. (1940). Die Übersprungbewegung [The skip movement]. *Zeitschrift für Tierpsychologie*, *4*, 1–40. <http://dx.doi.org/10.1111/j.1439-0310.1940.tb00616.x>
- Toner, I. J., Lewis, B. C., & Gribble, C. M. (1979). Evaluative verbalization and delay maintenance behavior in children. *Journal of Experimental Child Psychology*, *28*, 205–210. [http://dx.doi.org/10.1016/0022-0965\(79\)90084-5](http://dx.doi.org/10.1016/0022-0965(79)90084-5)
- Toner, I. J., & Smith, R. A. (1977). Age and overt verbalization in delay-maintenance behavior in children. *Journal of Experimental Child Psychology*, *24*, 123–128.
- Vick, S. J., Bovet, D., & Anderson, J. R. (2010). How do African Grey parrots (*Psittacus erithacus*) perform on a delay of gratification task? *Animal Cognition*, *13*, 351–358. <http://dx.doi.org/10.1007/s10071-009-0284-2>
- Wascher, C. A. F., Dufour, V., & Bugnyar, T. (2012). Carrion crows cannot overcome impulsive choice in a quantitative exchange task. *Frontiers in Psychology*, *3*, Article 00118 (6 pp.). <http://dx.doi.org/10.3389/fpsyg.2012.00118>

Appendix

Behavior Patterns Observed During Delays

Physical behaviors	Reward-related manipulations	Vocalizations
Attended to noise	Ate reward	“Go chair”
Excited/anticipatory behavior	Dropped reward to the floor	“Ink” (request to go to sink)*
Held foot up	Dropped reward back into cup	Species-specific noises**
Looked behind him	Licked reward	“Sss”
Opened/closed eyes (“sleepy”)	Looked at empty cup	“Want a/wanna nut”
Preened with beak	Looked at reward in cup	“Wanna corknut” (almond)
Scratched with foot	Moved cup away	“Want (go to) chair”
Shook feathers	Picked up reward	“Wanna go back” (to cage)
Shook head	Threw cup with reward to floor	
Shook tail	Touched reward with beak	
Slept? (Kept eyes closed)		
Stretched		
Touched foot with beak		
Wiped beak		
Yawned		

* “Sink” is a play area. ** Beeps, chirps, hoots, squeaks, etc.

Received September 16, 2014
 Revision received May 19, 2015
 Accepted June 11, 2015 ■