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BRIEF REPORT

Procrastination in the pigeon: Can conditioned reinforcement increase the likelihood of human procrastination?

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Abstract
Procrastination is the tendency to put off initiation or completion of a task. Although people are typically known to procrastinate, recent research suggests that they sometimes "pre-crastinate" by initiating a task sooner than they need to (Rosenbaum et al. in *Psychological Science, 25*(7), 1487–1496, 2014). A similar finding of precrastination was reported by Wasserman and Brzykcy (*Psychonomic Bulletin & Review, 22,* 1130–1134, 2015) with pigeons using a somewhat different procedure. In the present experiment, we used a procedure with pigeons that was more similar to the procedure used by Rosenbaum et al. Pigeons were given a choice between two sequences of events (concurrent chains). Choice of the procrastination chain resulted in color A, which 15-s later would change to color B and 5-s later resulted in reinforcement. Choice of the precrastination chain resulted in color C, which 5-s later would change to color D and 15-s later resulted in reinforcement. Thus, both chains led to reinforcement after 20 s. Results indicated that the pigeons procrastinated. That is, they preferred the 15-5 chain over the 5-15 chain. The results are consistent with Fantino's (*Journal of the Experimental Analysis of Behavior, 12,* 723–730, 1969) delay reduction theory, which posits that stimuli that signal a reduction in the delay to reinforcement, such as the 5-s stimulus that occurred immediately prior to reinforcement, serve as strong conditioned reinforcers and should be preferred. In support of this theory, the pigeons pecked most at the 5-s stimulus that led immediately to reinforcement, indicating that it had become a strong conditioned reinforcer. The results suggest that delay reduction theory, a theory that emphasizes the attraction to stimuli that predict reinforcement with a short delay, also may contribute to human procrastination behavior because when task completion comes just before the deadline, it may become a stronger conditioned reinforcer than if task completion comes earlier.

Keywords Procrastination · Pre-crastination · Delay reduction theory · Chain schedules · Pigeons

Procrastination is the tendency to delay initiating or completing a task. Considerable research has been devoted to the characteristics of personality and contexts that tend to result in human procrastination (Lay, 1986). There is even evidence that animals, such as pigeons, will put off making a required number of pecks, even if delaying the response requirement results in a substantial increase in the response requirement for reinforcement (Mazur, 1996). However, there is also research suggesting that humans may sometimes show the opposite effect. That is, subjects may respond sooner than they are required to, even if responding sooner increases the effort required to complete the task (Rosenbaum, Gong, & Potts, 2014), a result that they refer to as *pre-crastination*.

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In their study, human subjects were required to walk from a start line to a finish line and on the way to pick up one of two weighted buckets. They could either pick up a bucket that they encountered sooner or one that they encountered later. Logic would indicate that they should pick up the bucket later, but more of the subjects chose to pick up the bucket that they encountered sooner, despite the fact that it meant carrying the weighted bucket a longer distance. Rosenbaum et al. (2014) attributed the choice of the added cost involved in picking up the closer bucket to the desire to complete a subgoal, presumably to reduce their working memory load. However, the simple context suggests that actual memory load should not be an issue.

Wasserman and Brzykcy (2015) asked if a similar effect could be found in animals. To find out, they presented pigeons with a three-step task. In Step 1, the pigeon was required to peck a colored center key. The peck turned off the center key for 0.5 s, and then both the center key and one of the side keys was illuminated with the same color. In Step 2, the pigeon could choose either to peck the center key again or to peck the newly illuminated side key. Either peck turned off the center key and replaced the side key with star shape. In Step 3, a single peck to the star shape resulted in reinforcement. In Step 2, Wasserman and Brzykcy found that all of the pigeons learned to switch to the side key, rather than peck the center key again, i.e., they moved to the side key sooner than necessary. Wasserman and Brzykcy suggested that the star probably served as a conditioned reinforcer, because it always preceded reinforcement and a peck to the side key would more promptly be followed by the star than a peck to the center key.

The procedure used by Wasserman and Brzykcy (2015) was somewhat different from that used by Rosenbaum et al. (2014). Although the total time would be the same regardless of which key was pecked, if the second peck was made to the side key, the pigeon would already be at the location of the conditioned reinforcer, the star. Furthermore, the time from the second peck to access to the star would be slightly shorter. This argument suggests that delay reduction may play a role in this effect as well. Delay reduction theory, proposed by Fantino (1969), states that the effectiveness of a stimulus as a conditioned reinforcer may be predicted most accurately by the reduction in time to primary reinforcement correlated with its onset (see also Fantino et al. 1993). That is, if the onset of a stimulus appears temporally closer to reinforcement, it will become a better conditioned reinforcer. Fantino (1969) tested this theory using a choice between two sequences of events (concurrent chains) in which, in one condition, the pigeons could choose between a relatively short interval (initial link) that led to a relatively long interval (terminal link) or a relatively long interval that led to a relatively short interval. Fantino used the relative rate of pecking each alternative as a measure of the preference for that alternative, although there is some evidence that the rate of pecking is not always the best measure of preference (Williams, 1992). Fantino concluded "that choice behavior is determined by the degree of reduction in the expected time to primary reinforcement signified by entry into one terminal link, relative to the degree of reduction signified by entry into the other terminal link." (Fantino, 1969, p. 730). The shorter the time to reinforcement predicted by the onset of the terminal-link stimulus, the greater the preference should be for the initial link stimulus associated with that terminal-link stimulus. However, that preference should be lessened by the fact that the initial-link stimulus associated with the shorted terminal-link stimulus is much longer than the other initial-link stimulus. But as the longer initial-link stimulus is further removed from reinforcement, its negative effect should be much less than the positive effect of the shorter terminal-link stimulus. Thus, the net effect should be a preference for the shorter terminal0link stimulus, even if the total time to reinforcement is, on average, the same for both alternatives.

If delay reduction theory is applied to the procedure used by Rosenbaum et al. (2014), it would predict that people should procrastinate rather than precrastinate, and that pigeons would procrastinate as well, with a procedure that is more similar to the one used by Rosenbaum et al. than the one used by Wasserman and Brzykcy (2015). Specifically, if the total time to reinforcement is held constant, the pigeons should prefer the alternative that provides the shortest terminal link. Thus, the purpose of the present experiment was to test the prediction of delay reduction theory that pigeons would tend to procrastinate, using a procedure more similar to that used by Rosenbaum et al. (2014). In the present experiment, pigeons were given a choice between two chained schedules: (a) a signaled short (5 s) fixed interval schedule that led to a signaled longer (15 s) fixed interval schedule that led to reinforcement, and (b) a signaled long (15 s) fixed interval schedule that led to a signaled shorter (5 s) fixed interval schedule that led to reinforcement.

In a fixed interval schedule, the first response after the scheduled interval leads to either the next interval or to reinforcement. Fixed interval schedules were chosen for this study, because pigeons generally peck at a high rate at the end of each schedule, ensuring that the actual intervals are very similar to the scheduled interval and the schedule duration is relatively insensitive to the rate of pecking. Although the total time required from initiation of the chain to reinforcement was comparable for the two chains, according to Fantino (1969), the prediction was that "procrastination" would be found. That is, pigeons should prefer the 15-5-s chain over the 5-15-s chain. Of course, an important difference between the Rosenbaum study and the proposed study is, unlike the Rosenbaum study, in the present study there was no added cost to the precrastination alternative. But the absence of an added cost should make the precrastination alternative even more preferred.

Method

Subjects

The subjects were ten unsexed white Carneau pigeons, 5-8 years old, purchased from the Palmetto Pigeon Plant, Sumter, South Carolina. All of the pigeons had prior experience with simultaneous color discriminations. One of the pigeons died during the course of the experiment. All of the pigeons had free access to water and grit in a climate-controlled colony room that was maintained on a 12:12-h light/dark cycle. During the experiment, all pigeons were maintained at 85% of their free-feeding body weight and were cared for in accordance with the University of Kentucky's Animal Care Guidelines.

Apparatus

The experiment took place in a BRS/LVE (Laurel, MD) standard sound-attenuating operant test chamber measuring 34-cm high, 30-cm wide, and 35-cm across the response panel. Three circular response keys (2.54-cm diameter) were horizontally aligned on the response panel (spaced 6.0-cm apart from edge to edge) and were located 25 cm from the floor. A 12-stimulus in-line projector (Industrial Electronics Engineering, Van Nuys, CA) with 28-V, 0.1-A lamps (GE 1820) was mounted behind each of the three response keys to project white on the center key and on the side keys, red, yellow, blue, and green hues, as well as a white vertical line, and a white horizontal line on a black background. Reinforcement consisted of 1.5-s access to mixed grain (Purina Pro Grains, a mixture of corn, wheat, peas, kefir, and vetch) that was provided from a food hopper. A 28-V, 0.04-A lamp illuminated the hopper when reinforcement was delivered. A houselight (28-V, 0.04-A lamp) was mounted on the center of the ceiling of the chamber. Experimental events were controlled by a microcomputer and interface located in an adjacent room.

Procedure

Pretraining The pigeons were trained to peck the white stimulus on the center key and the other six stimuli on both of the side keys. Initially, one peck was required for reinforcement. The schedule of reinforcement for responding to the four colors was then changed to fixed interval 5 s (FI 5 s, the first response after 5 s provided reinforcement). Reminder trials with only a single peck required were included with white on the center key or a vertical or horizontal line on one of the side keys.

Once the pigeons were responding reliably, the pigeons began training on the chained schedules. All trials began with the white orienting stimulus projected on the center key. The purpose of the center key illumination was to ensure that the pigeon was oriented between the two side keys at the start of each trial. One peck to the white center key turned it off and turned on one of the side keys with either a vertical or a horizontal line. If the vertical line was presented, a single peck turned off the line and replaced it with a blue hue. Completion of an FI 5-s schedule turned off the blue hue and replaced it with a yellow hue. Completion of an FI 5-s schedule turned off the yellow hue and provided it with reinforcement. If the horizontal line appeared, a single peck turned off the line and replaced it with a green hue. Completion of an FI 5-s schedule turned off the green hue and replaced it with a red hue. Completion of an FI 5-s schedule turned off the red hue and provided it with reinforcement. Each session consisted of 30 vertical-blue-yellow trials and 30 horizontal-green-red trials.

Training Once the pigeons were able to complete a session in 25 min or less, they were assigned randomly to one of two groups for the purpose of counterbalancing. The design of the experiment appears in Fig. 1. For one counterbalancing group (n = 5), the FI schedule associated with the yellow stimulus and the green stimulus was first increased to FI 10 s and once responding had stabilized, the schedule associated with both stimuli was increased to FI 15 s. The schedule associated with the blue and red stimuli remained FI 5 s. For the other counterbalancing group (n = 4), the FI schedule associated with the blue and red stimuli was first increased to FI 10 s and then the schedule associated with both stimuli was increased to FI 15 s. Each of 30 training sessions involved 30 vertical line trials and 30 horizontal line trials.

Testing On testing trials, a peck to the center white stimulus presented both line orientation stimuli, one on each side key. Each of 10 testing sessions consisting of 40 training trials (20 vertical-blue-yellow and 20 horizontal-green-red trials) and 20 testing trials. Choice of either line extinguished the other line stimulus and resulted in the hue stimuli that followed that line during training.

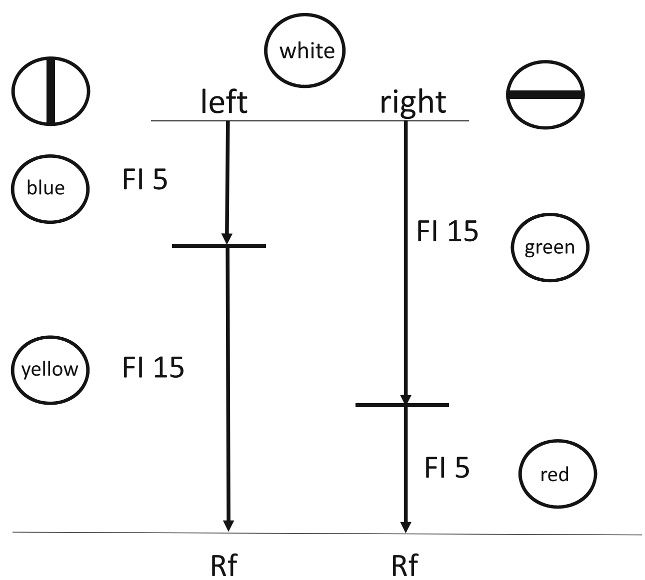

Fig. 1. Design of the experiment. During training, following the orienting response to the white center key, all pigeons received trials with either (**a**) the vertical line (single peck), followed by the blue stimulus (FI 5 s), followed by the yellow stimulus (FI 15 s), followed by reinforcement or (**b**) the horizontal line (single peck), followed by the green stimulus (FI 5 s), followed by the red stimulus (FI 15 s), followed by reinforcement. Each line could appear randomly on the left or right side key. During testing, the pigeons were given a choice between the vertical and horizontal lines. After choosing, they received the colors that they experienced in training. The design for the counterbalancing group is not shown.

Data analysis

Choice data were analyzed for changes over testing session using a one-way analysis of variance. Choice data, pooled over sessions, were analyzed using a single sample *t* test against chance (50%). Pecking rate to the four hues was also analyzed with a two-factor, repeated-measures analysis of variance with proportional initial-link rate and terminal-link rate as factors.

Results

Choice

The pigeons showed a clear preference for the 15-5 chain over the 5-15 chain (mean proportion choice of the 15-5 chain was 0.64 ± 0.03 SEM), and there was little change in the preference over test sessions, $F(9, 81) = 1.25$, $p > 0.05$. Data from the two counterbalancing groups did not differ, so the data were pooled. The results of choice on test sessions are presented in Fig. 2. A single sample *t* test on the choice data pooled over sessions indicated that the pigeons showed a significant preference for the 15-5 chain over the 5-15 chain, $t(8) = 4.22$, $p = 0.003$, $\eta_p^2 = 0.122$, indicating that the pigeons had a preference to procrastinate. The range of preference for the 15-5 chain was 0.59-0.72 across subjects. Thus, all of the pigeons showed some preference for the 15-5 chain.

Response rate

Pigeons pecked at a higher rate to the short schedule stimuli (FI 5 s) than the long schedule stimuli (FI 15 s), and they pecked at a higher rate to the terminal link stimuli than to the initial link stimuli. They also pecked more to the two stimuli associated with procrastination than to the two stimuli associated with precrastination. A graph of the proportional peck rate to each of the four color stimuli appears in Fig. 3. A two-way, repeated-measures analysis of variance was performed on the normalized peck-rate data (proportion of pecks to each of the four color stimuli relative to total pecks) to control for individual differences in overall peck-rate. The peck-rate analysis indicated that the proportion of pecks/s to the procrastination stimulus pair (mean = 0.60) was significantly greater than the proportion of pecks/s to the precrastination stimulus pair (mean = 0.40), $F(1,8) = 13.51$, $p = 0.006$, Cohen's $d = 2.60$ In addition, the proportion of pecks/s to the terminal link stimuli (mean = 0.58) was significantly greater than the proportion of pecks/s to the initial link stimuli (mean = 0.42), $F(1,8) = 12.34$, $p = 0.008$, Cohen's $d = 2.48$. Finally, there was a significant interaction of Procrastination/Precrastination x Initial-link/Terminal-link proportion of pecks (i.e., the proportion of pecks to short schedule stimuli vs. long schedule stimuli), which indicated that the pigeons pecked proportionally more to short schedule stimuli (mean = 0.80) than to long schedule stimuli (mean = 0.20), $F(1,8) = 30.81$, $p = 0.0005$, Cohen's $d = 3.92$.

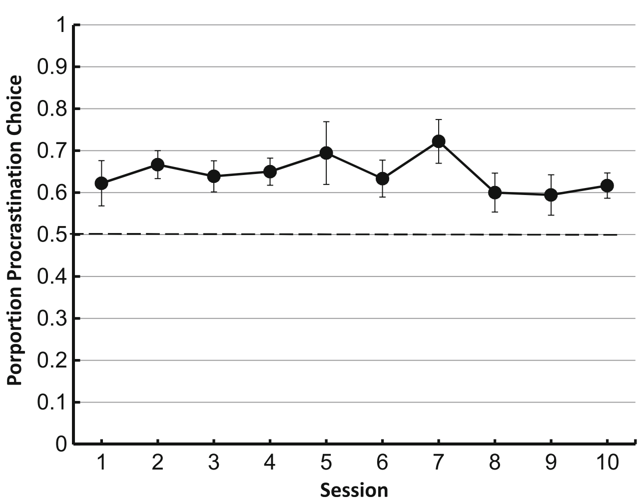

Fig. 2. Proportion of procrastination choices as a function of test session.

Discussion

The results of the experiment were in keeping with Fantino's (1969) delay reduction theory because terminal-link stimuli of shorter duration FI 5 s should be better conditioned reinforcers than terminal-link stimuli of longer duration FI 15 s. But one might expect the difference in the duration of the initial-link stimuli to compensate for the difference in duration of the terminal-link stimuli. However, given that the initial-link stimuli occur earlier than the terminal link stimuli, according to delay reduction theory, they should not play as important a role in the preference for the stimulus-response chain. That is, delay reduction theory would predict that they would choose to enter the terminal link later rather than sooner which they

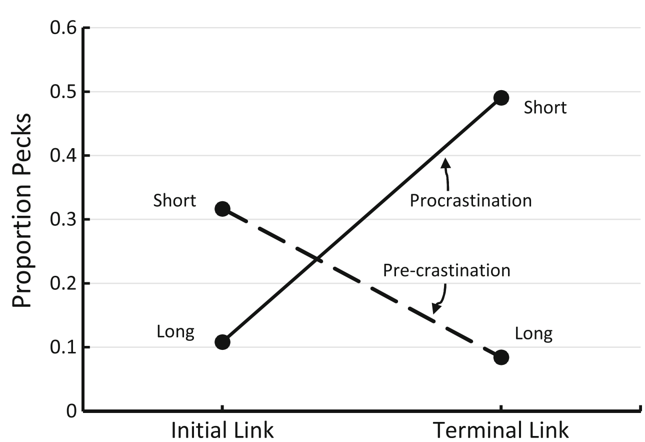

Fig. 3. Proportion of pecks/s to each of the colored stimuli seen during testing (pecking data were pooled over all 10 test sessions).

did, behavior suggesting that the pigeons were procrastinating.

The peck-rate data further clarify the results of the experiment. The fact that the pigeons pecked more, overall, at the terminal link stimuli than at the initial link stimuli is consistent with the fact that the terminal link stimuli were closer to reinforcement. Similarly, it would be expected that the pigeons would peck more, overall, at the stimuli associated with the shorter schedules than at the stimuli associated with the longer schedules because those pecks would lead to reinforcement or to the terminal link schedule sooner. The fact that the pigeons pecked more, overall, at the stimuli associated with the procrastination chain than to those associated with the precrastination chain is consistent with their significantly greater choice of that chain. It also is consistent with Fantino's delay reduction theory, because the source of that effect comes almost entirely from the high rate of pecking to the short-schedule terminal-link stimulus that predicts the shortest delay to reinforcement (Fig. 3).

The present results are inconsistent with the hypothesis that the results of Rosenbaum et al. (2014) concerning precrastination in the human bucket-carrying task would occur with pecking in pigeons. Rosenbaum et al. (2014) found evidence for precrastination by humans who chose to complete a subgoal of their task sooner rather than later, even though it meant that they would have to carry the bucket farther when they choose that alternative. In that task, one would have expected humans to put off the somewhat aversive event as long as possible, but they did not. Rosenbaum et al. cite cases in which, although two paths lead to the same destination, people who walk or drive indicate that "they are more likely to make a needed turn and travel a short distance before travelling a long straight distance, than they are to travel the long straight distance and then turn to complete the remaining short distance" (p. 1495). That is, taking the path that involves turning first creates the illusion of arriving sooner, because it completes a subgoal of the task earlier. In those cases, however, there is no additional effort involved in taking the turn-first route, whereas in the Rosenbaum et al. study, there is additional effort required when the subgoal is chosen earlier. Apparently, the benefit of arriving at the subgoal earlier outweighs the cost of carrying the bucket longer. In the present experiment, attainment of the subgoal did not have the added attraction for pigeons that it appears to have had for humans in Rosenbaum's study. Also, in the present experiment, unlike in the experiment with humans, there was no additional effort associated with the choice to enter the terminal link earlier. Given that the pigeons chose to procrastinate, however, had there been additional effort associated with entry into the terminal link, it should have only increased their tendency to procrastinate.

One could argue that the procedure in the current experiment lacks an important characteristic of the typical task that incurs procrastination, namely task aversion. In most tasks in which procrastination occurs, the task that is put off is not pleasant, but rising anxiety, especially when there is a deadline involved, eventually pressures one to begin. Although waiting 20 s for food might be considered aversive, the two alternatives should be comparatively equal in their aversiveness, and "putting off" entry into the terminal link by choosing the 15-5 alternative would not be thought to have the aversion delaying characteristic of what is typically considered procrastination. In the present article, the term procrastination is used in juxtaposition to Rosenbaum et al.'s (2014) term precrastination (i.e., the tendency not to delay reaching a subgoal). Thus, in that sense, our pigeons were engaging in procrastination (i.e., the tendency to delay reaching a subgoal).

How is one to reconcile the present findings with those of Wasserman and Brzykcy (2015)? As those authors suggested, in that experiment, switching to the terminal link location sooner allowed the pigeons to get physically closer to the location where they needed to be to receive the terminal link stimulus, the star. In the present experiment and in the Rosenbaum et al. (2014) study, completing the subgoal (picking up the bucket or entering into the terminal link) did not get the subjects closer to their goal (although for humans, it may have given them the illusion that it did). Thus, when the pigeon's behavior gets it spatially (and perhaps even temporally) closer to the goal (reinforcement), it will be preferred. For example, in a recent study by Navarro and Wasserman (2017), pigeons were trained to peck at a virtual object on a screen that moved the object a fixed distance toward a goal, resulting in reinforcement. When given a choice, pigeons preferred to peck at the object that was closer to the goal (or required fewer pecks to get to the goal) rather than one that was farther away. That is, the pigeons learned to choose the alternative that required less time and effort to reinforcement. Thus, the fact that the pigeons could immediately choose the object that got them closer to reinforcement would have shortened the absolute delay to reinforcement, a feature not present in either the Rosenbaum et al. study or the present experiment.

It is reasonable to question the relation between the present task used with pigeons (and the human bucket carrying task, as well) and the typical natural tendency that humans have to procrastinate (e.g., cleaning out a closet or starting to write a term paper). When people procrastinate, they put off completing a task and that incurs a delay in the reinforcement that comes from task completion. The delay puts off the aversiveness associated with working on the task. The increasing anxiety associated with putting off the task (e.g., the aversiveness of the messy closet or the looming approach of the paper deadline) is ultimately what motivates humans to complete the task. Thus, a traditional model of procrastination is the temporal discounting task (Howell, Watson, Powell, & Buro, 2006). Temporal discounting is typically studied in an appetitive context in which a small immediate reinforcer often is chosen over a larger delayed reinforcer (Ainslie, 1975). Temporal discounting also can be applied to aversive events in which a large delayed aversive event is chosen over a smaller immediate one (Deluty, 1978). In the Rosenbaum et al. (2014) experiments, because the terminal link actually does involve a somewhat aversive event (carrying the heavy bucket), subjects would have been procrastinating if they had picked up the later bucket, but they did not. In the present experiment, however, there should have been no advantage to procrastinating (i.e., choice of the 15-5 alternative over the 5-15 alternative).

Finding a procrastination effect in the absence of a differential aversive event suggests that conditioned reinforcement may identify an additional factor involved in procrastination, a possibility that, in practice, contributes to its choice. In the present task, according to delay reduction theory, the preference for the 15-5 alternative can be attributed to the added value of the shorter terminal-link stimulus, the conditioned reinforcer. In most examples of human procrastination, the aversiveness involved in the task presumably outweighs the benefit obtained from getting an early start. The results of the present study, however, suggest the possibility that past positive experience with procrastination (being able to complete a task after procrastinating) may increase the value of the effort that went into arriving at the goal through its close proximity to the goal via conditioned reinforcement (Fantino, 1969). Although Fantino's theory did not address the question of procrastination, completing a task in close proximity to the deadline may provide an additional source of conditioned reinforcement.

Thus, the present research has implications for identifying mechanisms responsible for human procrastination. It is well understood that task activity just before the deadline (or potential reinforcement) serves to relieve accumulating anxiety. In addition, the greater the anxiety, the greater relief there should be upon completion of the task, and that relief may serve as a better conditioned reinforcer (see Zentall, 2010) than when anxiety is lower. That is, when a deadline approaches and anxiety is greatest, the reduction in anxiety should have its greatest positive effect, thus reinforcing procrastination. Future research should investigate the role played by conditioned reinforcers and contrast in maintaining human procrastination behavior.

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