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DISTRACTORS AS A TOOL TO INCREASE “SELF-CONTROL” IN PIGEONS (*COLUMBA LIVIA*)

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Arts & Sciences
at the University of Kentucky

By

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2021

ABSTRACT OF THESIS

DISTRACTORS AS A TOOL TO INCREASE "SELF-CONTROL" IN PIGEONS (*COLUMBA LIVIA*)

In the successive delay-discounting task, all trials start with a stimulus to which a response results in a small amount of reinforcement (smaller-sooner). If no response is made, the stimulus changes and a response results in a larger reinforcer (larger-later). The purpose of this study was to examine the use of a non-reinforced distractor (a stimulus to which responding has no programmed consequence) as a method of increasing the proportion of larger-later (LL) choices in a successive delay-discounting task. Earlier research studying the use of distractors may have inadvertently associated the distractor with reinforcement. Four experiments were conducted and each focused on a different aspect of the procedure: prior reinforced training with the distractor, increased experience with the delay-discounting task, inclusion of a constant delay between choice and reinforcement, and the presence of a response-dependent LL stimulus, respectively. Contrary to what has been found in previous studies, the results from the first 3 experiments suggest that there is little evidence that pigeons will use a non-reinforced distractor in order to obtain a greater amount of reinforcement, while the fourth found a significant distractor effect. Further research is necessary to examine the efficacy of a distractor in a successive delay-discounting task.

KEYWORDS: Delay discounting, self-control, distractors, commitment

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CHAPTER 1. INTRODUCTION

1.1 "Self-control" and Impulsivity

Self-control is often defined as opting for a larger reinforcer available after a long delay (i.e., the larger-later or LL alternative) over a smaller reinforcer available after a short delay (i.e., the smaller-sooner or SS alternative) (Ainslie, 1974; Mischel et al., 1989; Rachlin & Green, 1972). In doing so, subjects may wait in anticipation of a greater reward rather than impulsively choosing an immediately available, but smaller reward. Laboratory research involving nonhuman animals has demonstrated that they often tend to opt for the impulsive choice (Ainslie, 1974), but can exhibit "self-control" after some training with the testing procedure (Beran et al., 2014; Osvath & Osvath, 2008; Tobin & Logue, 1994) or when trained with secondary reinforcers (Ballard et al., 2017; Danziger, et al., 2011; Gailliot, 2013; Hackenberg & Vaidya, 2003; Jackson & Hackenberg, 1996; Read & van Leeuwen, 1998; Vollmer et al., 1999).

A commonly used equation to model delay-discounting is the hyperbolic function

$$\mathrm{V} = \frac{A}{1 + kD} \tag{1}$$

where *V* is the subjective value of a given alternative, *A* is the magnitude of the delayed reinforcement, *k* is the subjective rate of discounting, and *D* is the delay to receiving the delayed reinforcement (Green et al., 2004; Mazur & Bondi, 2009). Manipulating the magnitude of reinforcement as well as the delay to reinforcement should, therefore, influence the likelihood of a subject opting for the LL alternative. Where humans are typically affected by the magnitude of reinforcement (*A*), as larger amounts of reinforcement are discounted at a slower rate than smaller amounts of reinforcement

(Ballard et al., 2017; Mazur & Bondi, 2009; Raineri & Rachlin, 1993), pigeons and rats do not appear to display as robust a magnitude effect as that seen in human participants (Green et al., 2004; Holt & Wolf, 2019; Oliveira et al., 2013; Ostaszewski et al., 2003; Richards et al., 1997). Such is not to say that nonhuman animals are insensitive to the magnitude of each alternative, so much as humans appear to be more strongly influenced by the magnitude of reinforcement while laboratory animals are affected more by the duration of the delay (Holt & Wolf, 2019).

Prior literature suggests that self-control is associated with a number of other behaviors, including aggression (DeWall et al., 2011; Miller et al., 2010), psychopathology (DeWall et al., 2012; Mitchell, 2017), religiosity (Renzetti et al., 2017), substance use (DeWall et al., 2014; Kollins, 2003; Mitchell, 2017), and crime (Lee et al., 2017). It is thus of great import to investigate the methods by which individuals can increase the expression of self-control behavior in a variety of situations, even (and especially) when the suboptimal impulsive option is sufficiently tempting. However, factors other than sheer willpower can influence self-control.

1.2 Commitment Procedures

It has been suggested that allowing subjects to commit to their choice (either the SS alternative or the LL alternative) prior to the choice itself results in increased self-control (Perrin & Neef, 2012; Rachlin & Green, 1972; Siegel & Rachlin, 1995). This type of commitment procedure produces similar results across species, as Rachlin and Green (1972) found that pigeons increase their proportion of LL choices when confronted with a commitment procedure depicted in Figure 1.1 (p. 16). By committing to choosing the LL alternative prior to the SS-LL choice, subjects may be using a form of self-regulation.

That is, when later confronted with the SS-LL choice, subjects may learn that they will be too impulsive to refrain from choosing the SS alternative, and thus initially should opt to choose the LL alternative now to resist the temptation of the SS (Rachlin & Green, 1972).

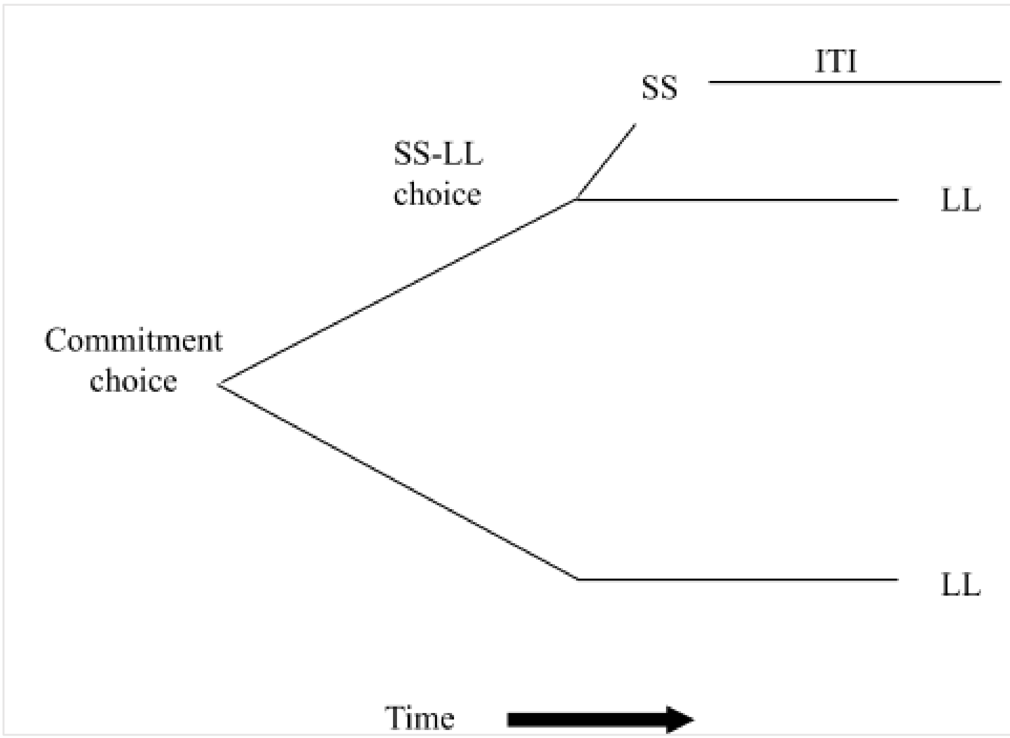

Figure 1.1 Commitment Procedure
A commitment procedure as described by Rachlin and Green (1972). When confronted with the commitment choice, pigeons are allowed to choose to either commit to the larger-later alternative (LL) or make a choice between the smaller-sooner (SS) or LL alternative later. Adapted from "Commitment, choice, and self-control" by H. Rachlin & L. Green, 1972, *Journal of the Experimental Analysis of Behavior*, *17*(1), 16.

In addition, it should follow that implementing a commitment procedure will translate Equation (1) further in time, thus making the LL alternative more subjectively valuable when the committed choice is presented than when the non-committed choice is presented (Zentall, 2020; Zentall et al., 2017; Zentall & Raley, 2019).

1.3 Methods of Decreasing Impulsive Behavior

Although a large body of literature suggests that humans tend to be more self-controlled than nonhuman animals, it is certainly not uncommon to find impulsive behavior in humans, especially when using food as reinforcement and in developmental studies involving children (Juanico et al., 2016; Newquist et al., 2012). Mischel and his colleagues, for example, conducted a series of experiments with preschool children investigating methods that would best curb impulsive behavior (Mischel, 1974; Mischel & Baker, 1975; Mischel & Ebbesen, 1970; Mischel et al., 1970; Mischel & Staub, 1965). In one such study, Mischel and Ebbesen (1970) examined the relationship between impulsivity and visibility of more- and less-preferred reinforcers and found that children were more likely to choose the less preferred (but immediately available) reinforcer when both reinforcers were visible; in another study, Mischel et al. (1972) studied the use of toys and directed thought patterns as a method of self-distraction to aid in successfully waiting for a salient food reinforcer. Similarly, Newquist et al. (2012) examined the use of several methods of self-regulation to increase self-control, including the use of timers, rules, and toys, finding that repeating rules or the use of a countdown timer did not increase self-control, but that playing with distracting toys did — similar to the findings originally reported by Mischel et al. (1972).

In the following experiments, a delay training procedure similar to that used by Newquist et al. (2012) was employed to gradually lengthen the duration of the initial SS stimulus before the appearance of the LL stimulus. In that study, human children were able to wait increasingly longer periods of time with a gradual delay training procedure (Newquist et al., 2012; Schweitzer & Sulzer-Azaroff, 1988). With this procedure, in each of the present experiments, a delay was determined at which the pigeons were incapable of waiting for the offset of the SS stimulus at least approximately 50% of the time.

1.3.1 Using Distractors to Decrease Impulsive Behavior

Nonhuman animals, like humans, may be able to employ self-regulatory methods, such as commitment and distraction, in order to increase the expression of self-control behavior, measured by an increased proportion of LL choices on a delay-discounting task. For example, chimpanzees were capable of using distracting toys as a method of self-regulation in an accumulation task in order to obtain a larger magnitude reinforcement (Evans & Beran, 2007). In that experiment, up to 36 candies were dropped down a clear tube, one every 30 s, and chimpanzees were allowed to disconnect the tube at any point during the session in order to obtain the candies that had already fallen at the cost of ending the trial. The chimpanzees were able to accumulate significantly more candies when they were provided toys in their enclosure prior to candies dropping down the tube (Evans & Beran, 2007). These findings seem to parallel those seen in human children using other types of delay-discounting tasks (Miller & Karniol, 1976; Mischel et al., 1972; Newquist et al., 2012).

Using a “distractor key” in lieu of toys, Grosch and Neuringer (1981) conducted a study to investigate the effect of distractors on pigeons’ impulsive behavior. Pigeons were presented with a red key that remained illuminated for either 5 s or 15 s. If the pigeon pecked at the illuminated red key, it was provided with a less-preferred reinforcer, but if it waited for the red key to turn off, it was presented with a more-preferred reinforcer. To decrease the proportion of SS choices, measured by pecks to the red key, the pigeons were given a distractor analogous to toys used in Mischel et al.’s (1972) experiment. A white distractor key was illuminated on a wall opposite to the panel that contained both the red key and hoppers; pigeons were initially trained to peck this white key (fixed ratio, FR20) for 1 pellet of reinforcement. Three different blocks of testing were conducted, one in which the white key was inaccessible by covering it with black tape ("No toy"), one in which pecks to the white key were still reinforced in addition to the reinforcement received for waiting for the red key to turn off ("Toy, FR20"), and another in which the white key was illuminated but did not provide reinforcement when pecked ("Toy, no FR"). In the "Toy, no FR" block of testing, even though pecking the white key was not reinforced, Grosch and Neuringer (1981) found that it was successfully used to refrain from choosing impulsively.

Similarly, in assessing negative automaintenance in pigeons, Williams and Williams (1969) provided pigeons with an alternate key that had no programmed effect. When reinforcement was delivered on a fixed-interval schedule contingent on the inhibition of pecks to one illuminated key, pigeons had a relatively difficult time resisting pecking the key. However, when provided with an alternate stimulus that was illuminated on a different key and neither provided reinforcement nor terminated the trial, pigeons learned to peck at that key instead of the one negatively contingent on a response (Williams & Williams, 1969).

Taken together, the findings from Mischel et al. (1972), Newquist et al. (2012), Evans and Beran (2007), Williams and Williams (1969), and Grosch and Neuringer (1981) suggest that providing an alternate activity can help subjects demonstrate self-control.

1.3.2 Pavlovian Logic Behind Distractor Use

Using a classical conditioning paradigm, it should follow that subjects will treat the distractor as a higher-ordered conditioned reinforcer. In a successive delay-discounting framework, the LL stimulus immediately follows the offset of the SS stimulus and, after a response, immediately precedes LL reinforcement. When a distractor is introduced, it should follow that if pigeons peck at the distractor stimulus as the SS stimulus turns off and the LL stimulus turns on, an association between pecking the distractor and the onset of the LL stimulus will be formed. Further, pecking the LL stimulus incurs LL reinforcement, and thus an association between the distractor stimulus and LL reinforcement (separated, of course, by a response to the LL stimulus) should be formed.

This categorization of the distractor stimulus as a higher-ordered conditioned reinforcer may be weakened by one of two ways: (1) the pigeon pecks at the distractor prior to the offset of the SS stimulus and makes a response to that, thus generating a competing association between the distractor stimulus and SS reinforcement, and (2) the distractor stimulus is pecked in extinction long after the onset of the LL stimulus on any given trial, and thus the distractor is found to be neutral at best and punishing at worst. Either of these two issues may provide competition with the association of the distractor stimulus as being a step removed from incurring LL reinforcement.

That being said, however, (1) is unlikely to occur at sufficiently short SS durations. It would be difficult for a subject to make a response to the distractor and have time to peck at the SS stimulus prior to its offset. Further, (2) would only be of consequence if the subject found pecking the distractor without direct reinforcement to be more punishing than finding its use as a higher-ordered conditioned reinforcer for LL reinforcement rewarding.

In the Grosch and Neuringer (1981) study, the LL reinforcement immediately followed the offset of the SS stimulus. This may have introduced an issue with the way in which the use of the distractor was implemented. Since pigeons were provided a less-preferred reinforcer if they pecked the SS stimulus while it was illuminated and were reinforced with a more-preferred reinforcer when it turned off, they were not required to respond to a stimulus prior to receiving the more-preferred reinforcer. Thus, in their study, pecking the distractor key may have been adventitiously reinforced had the pigeon been pecking the distractor key when the red key turned off.

By not requiring a separate response before providing the more-preferred reinforcer like those employed in Mischel et al.'s (1972) and Newquist et al.'s (2012) studies, Grosch and Neuringer (1981) may have inadvertently reinforced pecking the white distractor key during the phase of the experiment in which pecks to the white key were not meant to be reinforced. In addition, Grosch and Neuringer (1981) originally trained the pigeons to peck the white distractor key prior to testing and sessions with the distractor key on an FR20 schedule occurred prior to sessions with the distractor without reinforcement. As a result, responses to the white distractor key would have been made in extinction. It is possible that there were carryover effects from the period of reinforcing white key pecks during training and testing during the "Toy, FR20" sessions.

1.4 Delay-Discounting Tasks

There are a number of different tasks that may be employed to assess impulsivity. Perhaps the simplest and most common is a simultaneous delay-discounting task, in which the SS and LL stimuli are presented at the same time and appropriate reinforcement follows after some delay once either the SS or LL is chosen. Other tasks exist, however, like the accumulation task described previously (Beran et al., 2016; Evans & Beran, 2007) or a rotating tray task, in which different magnitudes of reinforcement are placed into two cups set on a rotating disk such that cups pass in front of the subject one at a time and cups are baited with increasingly larger amounts of reinforcement as long as the subject does not take the reinforcement as it passes them (Beran et al., 2016; Bramlett et al., 2012). The task employed in the present study is a successive delay-discounting task similar to that used by Grosch and Neuringer (1981). In this task, an SS stimulus appeared for a fixed duration of time and provided SS reinforcement when pecked; otherwise, if left unpecked, it would change to an LL stimulus, which required a response prior to providing LL reinforcement. This task is different from that employed by Grosch and Neuringer (1981) in that it required a response to a separate LL stimulus in order to receive LL reinforcement.

1.5 Introduction to Present Experiments

Four experiments were conducted. The first aimed to address the issue of reinforced training to respond to the distractor key prior to testing by including a condition without reinforcing pecks to the distractor. In the second experiment, a potential novelty effect associated the distractor stimulus was further investigated. Following research suggesting that delay of reinforcement may decrease overall impulsivity (Zentall, 2020; Zentall et al., 2017; Zentall & Raley, 2019), the third experiment introduced a constant delay between choice and reinforcement in an attempt to increase the duration of the SS stimulus that the pigeons were willing to endure before pecking it and, by extension, increase the potential for pecks to the distractor stimulus to occur. Finally, the fourth experiment examined the differences in procedures employed by Grosch and Neuringer (1981) and the previous three experiments — namely, that of the inclusion of a separate LL stimulus that required a peck response prior to receiving appropriate reinforcement.

Although Evans and Beran (2007) and Grosch and Neuringer (1981) presented the distractor stimulus over the course of an entire session, in Experiments 1, 3, and 4, the distractor stimulus was randomly presented on half of the trials in each session, similar to the presentation described by Mischel et al. (1972) and Newquist et al. (2012). Experiment 2 presented the distractor on every trial per session in a manner similar to that employed by Grosch and Neuringer (1981) and Evans and Beran (2007).

CHAPTER 2. EXPERIMENT 1

2.1 Introduction

It was hypothesized that subjects trained with the white key would be more likely to peck the white key during testing — as a result, those birds that received training with the distractor used during testing should have had a greater number of LL choices on trials when the distractor key was present compared to trials when the distractor key was absent; in addition, they should have had a greater number of LL choices on trials with the distractor key than subjects that had not received prior reinforced training with the distractor key.

2.2 Methods

2.2.1 Subjects

Twelve experimentally experienced pigeons originally purchased from the Palmetto Pigeon Plant (Sumter, SC) and Double T Lofts (Edmond, OK) were used in the experiment. The pigeons had prior experience making simultaneous color discriminations. The pigeons were housed in individual wired cages measuring 28 cm x 38 cm x 30.5 cm on a twelve-hour light/dark cycle. Over the course of the experiment, all pigeons were maintained at 85% free feeding weight and were given free access to grit and water. They were cared for in accordance with University of Kentucky animal care guidelines.

2.2.2 Apparatus

A Med Associates (St Albans, VT) ENV–008 modular operant test cage was used. The response panel in the chamber had a horizontal row of three response keys. Only the left and right response keys were used in the present experiments. Behind each key was a 12-stimulus inline projector (Industrial Electronics Engineering, Van Nuys, CA) that projected red, blue, green, and white colored light, as well as a variety of black shapes. Reinforcement was delivered by a pellet dispenser mounted behind the response panel (Med Associates ENV–45). A 28 V, 0.1 A house light was centered above the response panel. A computer in the adjacent room controlled the experiment.

2.2.3 Training Procedure

At the start of each trial, the SS stimulus (a red light) was illuminated on either the left or right key, followed by the LL stimulus (a green light) on the same key if the pigeon had not pecked the red light. The duration of the red light started at 0.5 s before turning to green. This was done to give the pigeon experience with the red key switching to green. If the subject pecked the red key before it changed to green at any point in the delay training procedure, it received 1 pellet of reinforcement and the trial was terminated. All trials were followed by a 5 s intertrial interval during which the house light illuminated the dish into which the pellets dropped. The house light illuminated all reinforcements and remained lit for all intertrial intervals in the present study. If the pigeon waited for the red key to change to green before responding, it received 5 pellets of reinforcement and the trial was then terminated. A 5 s intertrial interval followed a response to either the red light or the green light. The red key duration was gradually increased in several steps (0.5 s, 1 s, and 2 s). The subjects were unable to resist pecking the red key more than approximately 50% of the time when the red duration was set at 2 s; as a result, this was the duration used during testing. Training on the delay procedure consisted of 4 sessions of 64 trials. Sessions were conducted daily.

Following the delay training procedure, pigeons were randomly assigned to one of two training conditions: one that received prior training with the white distractor key, and one that received prior training with a blue key, a color not used later in testing, to equate the groups for prior training. Training with the white or blue stimulus involved a variable-interval 10 s schedule of reinforcement. Responses after the variable interval were reinforced with 1 pellet. The white or blue stimulus location was randomized on the two side keys. Only the group of subjects randomly assigned to white key training had experience with the distractor key later used in testing. Thus, for birds randomly assigned to the blue key training group, the white distractor key used in testing was novel. Training with the blue or white stimulus consisted of 4 sessions of 64 trials. Sessions were conducted daily. As such, training between the two phases prior to testing consisted of 8 sessions total.

2.2.4 Testing Procedure

During testing, the red key was illuminated on either the left or right key at the beginning of each trial and its color changed to green after 2 s with no response; if it was pecked before the 2 s had elapsed, it resulted in 1 pellet of reinforcement and terminated the trial. If the pigeon did not peck for 2 s, the key changed to green and it remained lit until it was pecked. When the green key was pecked, it resulted in 5 pellets of reinforcement and the trial was terminated.

For both training groups, distractor trials during testing had the white key illuminated simultaneously with the red light on the other key (e.g., if the red key was presented on the right, the white key appeared on the left and vice versa). The white stimulus (the “distractor”) remained illuminated until either the red or green light had been pecked. Pecks to the white key were recorded but had no programmed effect. Testing sessions consisted of 64 trials, such that 32 randomized trials employed the white distractor key and 32 did not. Experiment 1 consisted of 8 testing sessions that were conducted 6 days a week. On Session 5, the distractor key was changed from a white light to black-and-white horizontal stripes for subjects in both training groups.

2.3 Results

Prior to the introduction of the white distractor key, the blue key training group (*M* = 12.42, *SD* = 8.03) did not have a significantly different number of green choices during the baseline delay training compared to the white key training group (*M* = 14.33, *SD* = 17.92) prior to the introduction of the white distractor key, $t(5) = 0.22$, $p = 0.84$.

To analyze the differences between LL choices on trials with and without the distractor by training group, a 2x2 mixed-factor analysis of variance (ANOVA) was conducted; contrary to what was hypothesized, there was not a significant difference between LL choices with and without the distractor for either training group, $F(1, 10) = 0.75$, $p = 0.41$. As a result, for all further analyses of the data from this experiment, the total number of LL choices (both those on trials with the distractor and those without the distractor) was used as the dependent variable. The results of Experiment 1 appear in Figure 2.1.

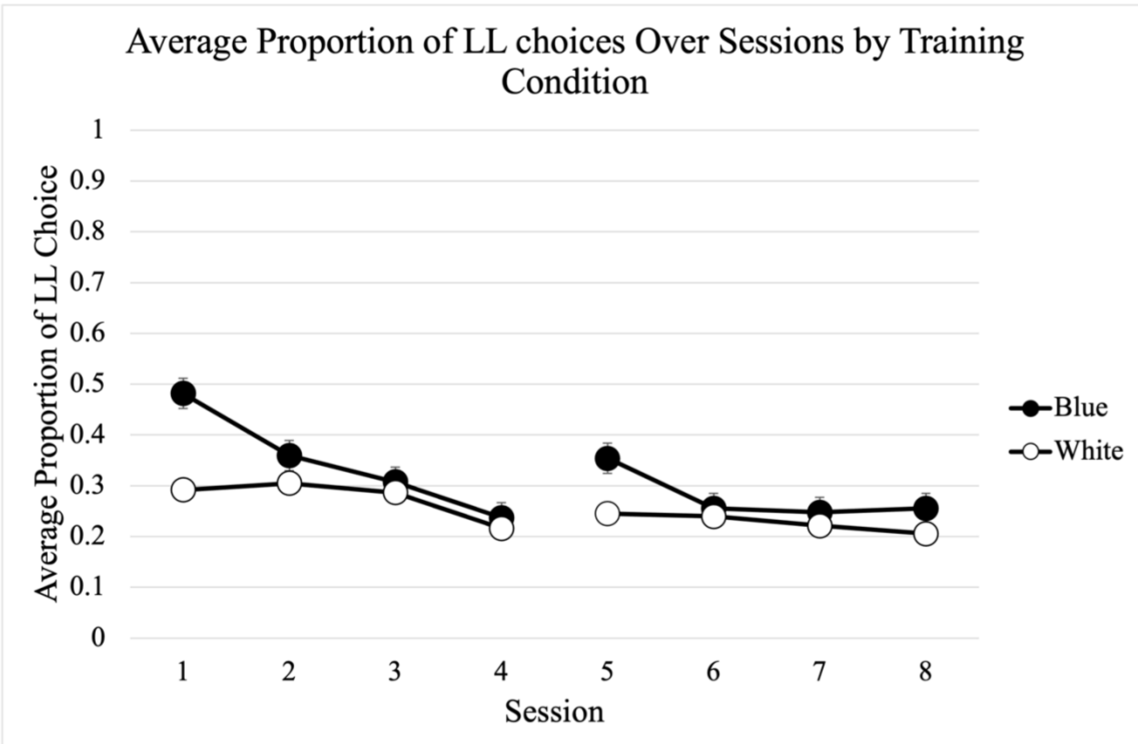

Figure 2.1 Results of Experiment 1
The average proportion of LL choice on trials with and without the distractor key is plotted by session and training group. The baseline number of LL choices, averaged over both groups, is indicated by the dashed line. Error bars represent the standard error.

Further, also inconsistent with the original hypothesis, the blue key training group ($M = 30.83$, $SD = 16.57$) had an increased number of net LL reinforcements compared to the white key training group ($M = 18.67$, $SD = 20.33$) on the first session that introduced the white distractor key in testing, $t(5) = 2.3$, $p = 0.04$, with a moderately large effect size ($d = 0.66$). This effect, however, quickly dissipated over the course of the next three sessions as the average number of LL choices for both groups approached baseline (see Figure 2.1). Thus, the effect for the blue key training group appeared to be a novelty effect. On Session 5, with the introduction of the new distractor stimulus, the blue key training group ($M = 22.67$, $SD = 16.56$) had somewhat more LL reinforcements than the white key training group ($M = 15.67$, $SD = 16.92$), but that difference was not statistically significant, $t(5) = 1.85$, $p = 0.06$. Additionally, the difference between the average number of LL choices for subjects in the blue key training group between baseline ($M = 12.42$, $SD = 8.03$) and Session 5 ($M = 22.67$, $SD = 16.56$) was not statistically significant, $t(5) = 1.47$, $p = 0.10$, suggesting that neither the blue key training group nor the white key training group experienced a novelty effect with the introduction of the new distractor stimulus.

The number of pecks to the white distractor key was recorded, but the difference between the number of distractor pecks averaged over all eight sessions for the blue key training group ($M = 8.81$, $SD = 8.81$) and the white key training group ($M = 1.63$, $SD = 1.53$) was not significant, $t(5) = 1.90$, $p = 0.12$. Further, the number of white pecks on Session 1 between the blue key training group ($M = 54.67$, $SD = 64.96$) and the white key training group ($M = 2.00$, $SD = 2.37$) did not differ significantly, $t(5) = 2.01$, $p = 0.10$.

2.4 Discussion

Given the fact that both of the pigeons used in Grosch and Neuringer's (1981) second experiment had received prior reinforced training with the white key, Experiment 1 aimed to observe the effects of the distractor for subjects that received training with and without the distractor. Prior reinforced training on a stimulus that was not employed in testing (i.e., the blue key) resulted in an increase in LL choices compared to the group that received prior reinforced training on the distractor stimulus that was used during testing (i.e., the white key).

While there was a significant difference in the proportion of LL reinforcements received between the blue key group and the white key group, this difference was only observed in the first session. Given the neophobic nature of pigeons and the nature of the delay-discounting task employed in that the LL stimulus was presented following the offset of the SS stimulus, it is possible that pigeons in the group that had not seen the distractor stimulus during their training were sufficiently distracted by it in this first session, thus resulting in a greater proportion of LL reinforcements. It would follow, therefore, that as this distractor stimulus was presented on the following sessions, its novelty wore off for both groups, and their proportion of LL reinforcements returned to baseline.

Further, contrary to the original hypothesis, there was not a significant consistent difference between LL choices with and without the distractor for either training group. It is possible that, while there was an increased proportion of LL reinforcements received overall for subjects in the blue key group, they were distracted on all trials by searching for the novel distractor stimulus; this may not have been observed for subjects in the white key group, as they had already had prior training with the white key.

In an attempt to determine if the difference observed between the two training groups was due to a novelty effect, a new distractor key that was novel to both groups was introduced. This new distractor, however, did not result in a significant renewed novelty effect for either group. It is possible that subjects in both groups had grown accustomed to seeing new stimuli in the context of this experiment, or they had learned that only the red and green keys would provide them with reinforcement directly and all other stimuli were extraneous.

As a result of these findings, a new experiment was designed to further examine the use of distractors presented consistently on all trials over blocks of sessions, as employed in studies conducted by Grosch and Neuringer (1981) and Evans and Beran (2007), as well as to determine any persisting effects of a distractor following its removal from the experiment.

CHAPTER 3. EXPERIMENT 2

3.1 Introduction

The purpose of Experiment 2 was to assess the reliability of the apparent novelty effect found in Experiment 1 and to determine if the experience with the novel distractor stimulus would carry over to sessions without the distractor. Additionally, it was of interest to see if the distractor would be more effective if presented for all trials over the course of a session rather than presented randomly on half of the trials in a given session.

It was hypothesized that the group that received sessions with the distractor followed by sessions without the distractor (group D-ND) would have an increased number of LL choices on experimental sessions, which contained the distractor key, compared to control sessions, which did not. Additionally, it was hypothesized that group D-ND would have a larger number of LL choices on control sessions compared to the group that received control sessions followed by experimental sessions (group ND-D). If the distractor key encouraged group D-ND to wait for the green key to appear and, as a result, they no longer needed the distractor key to help them wait, they should have a greater number of LL choices on control sessions compared to group ND-D. Further, following the results of Experiment 1, group ND-D should not have an increased number of LL choices with greater experience on the task.

3.2 Methods

3.2.1 Subjects

Twelve different pigeons similar to those described in Experiment 1 were used.

3.2.2 Apparatus

The same apparatus as described previously was employed in the present experiment.

3.2.3 Training Procedure

The delay training procedure described in Experiment 1 was used in the present experiment. Given the results found in Experiment 1 suggesting that prior reinforced training with the distractor to be used in testing did not significantly increase the number of LL choices except for a possible novelty effect, the present experiment did not employ a training procedure with the distractor key. Subjects received 10 training sessions, each consisting of 64 trials. The point at which subjects were unable to resist pecking the red key more than approximately 50% of the time was 1.5 s (compared to 2 s in the first experiment). As a result, the red key remained illuminated for 1.5 s before changing to green during testing in Experiment 2. Training consisted of 9 sessions of 64 trials. Sessions were completed 6 days a week.

3.2.4 Testing Procedure

The birds were assigned to one of two groups. Subjects were ranked in descending order by the average number of LL choices in the sessions prior to testing and were assigned to each experimental condition in a counterbalanced manner. After delay training, group ND-D received sessions with the distractor key after sessions without it and group D-ND received sessions with the distractor key prior to sessions without it. Experimental sessions consisted of 64 trials, all of which contained one key that had the red light followed by the green light if the pigeon did not peck the red light. If the pigeon pecked the red light, it received 1 pellet. If it waited for the offset of the red light and pecked the green light, it received 5 pellets. The other key contained the distractor stimulus on experimental sessions only. Control sessions consisted of 64 trials without the distractor key. Experimental sessions consisted of 64 trials with the distractor key.

Testing sessions were conducted in a similar manner to that described in Experiment 1, with the exception that red duration used during testing was 1.5 s (instead of 2 s, as used in Experiment 1). The distractor key was a set of black-and-white vertical stripes instead of a white light. Testing consisted of 18 sessions (9 control sessions and 9 experimental sessions) of 64 trials. Sessions were completed 6 days a week.

3.3 Results

There was not a significant difference in the number of LL reinforcements at baseline prior to testing between group ND-D (*M* = 24.54, *SD* = 14.45) and group D-ND

(M = 25.29, SD = 19.58), $t(5) = 0.09$, $p = 0.93$. A 2x2 mixed-factor ANOVA was conducted to assess the main effects of condition order (ND-D or D-ND) and distractor presence (present or absent), as well as the interaction effect. Neither the main effect for condition, $F(1, 10) < 0.01$, $p = 0.96$, nor the main effect for distractor presence, $F(1, 10) = 0.09$, $p = 0.77$, were statistically significant; the interaction effect of distractor presence and condition order, $F(1, 10) = 1.43$, $p = 0.26$, was also not significant. The number of distractor pecks was recorded, but the difference between the number of distractor pecks averaged over all sessions with the distractor key present for group ND-D (M = 6.27, SD = 9.21) and group D-ND (M = 3.90, SD = 3.71) was not statistically significant, $t(5) = 0.53$, $p = 0.62$. The results of Experiment 2 appear in Figure 3.1.

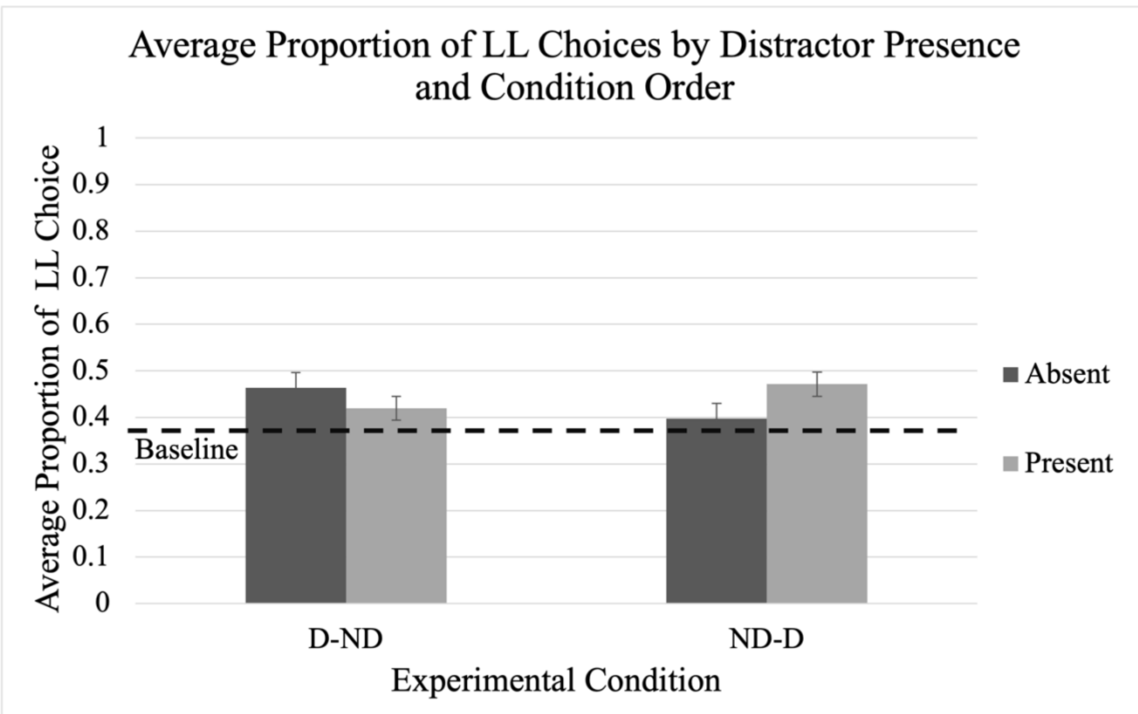

Figure 3.1 Results of Experiment 2
The average choice of green on between condition order (ND-D and D-ND) as well as by sessions containing the distractor and those in which the distractor was absent. The baseline number of green choices, averaged over both groups, appears as a dashed line. Error bars represent the standard error.

As seen in Figure 3, the average number of LL choices was similar regardless of distractor presence on testing sessions or condition order. The difference between the number of LL choices made during testing (by taking the average of green choices during control sessions and experimental sessions) and the number of LL choices made during baseline prior to testing by condition served as the dependent variable for the paired-samples *t*-test. The difference scores between group ND-D (M = 3.26, SD = 11.01) did not differ significantly from group D-ND (M = 2.97, SD = 7.78), $t(5) = 0.06$, $p = 0.95$.

3.4 Discussion

Contrary to hypothesis, there was little difference in the number of LL choices based on distractor presence. Consistent with trends observed in Experiment 1, it did not appear that increased experience with the delay training procedure produced an increase in the number of LL choices, as there was no significant increase in green choices for the group that received sessions without the distractor after training prior to sessions with the distractor after training (group ND-D). The absence of a significant effect due to the distractor suggests that it may be necessary to have the distractor stimulus present on some trials and absent on others within a session, as the distractor may not be sufficiently salient when constantly presented over several sessions.

Additionally, as the proportion of LL choices observed for subjects in group D-ND did not change significantly, it is unlikely that the distractor had persisting effects after its removal. This is an important finding, as it suggests that subjects did not learn how to effectively utilize any distracting stimulus in their environment to avoid choosing the SS stimulus, nor were they dependent on the presence of the supplied distractor stimulus to avoid pecking the SS stimulus.

As neither a novelty effect nor a significant effect due to experimental manipulations were observed, a new experiment was designed in an attempt decrease the proportion of SS choices overall, in addition to testing the use of the non-reinforced distractor.

CHAPTER 4. EXPERIMENT 3

4.1 Introduction

There is evidence to suggest that inserting a constant delay between choice and reinforcement can decrease impulsivity in pigeons (Zentall, 2020; Zentall et al., 2017; Zentall & Raley, 2019). The logic of this delay of reinforcement is a continuation of the aforementioned commitment procedure proposed by Rachlin and Green (1972). If Equation (1) accurately describes the functions by which animals decide between two outcomes in a delay-discounting framework, forcing subjects to commit at an earlier point in time makes the LL choice relatively more valuable than the SS alternative (see Figure 4.1). It is difficult to resist obtaining food immediately, but if the subject must wait 5 s for the smaller magnitude of reinforcement, it is relatively less aversive to wait the additional 5 s to obtain the larger magnitude of reinforcement. By this logic, the constant delay should allow the pigeon to wait longer in the presence of the SS without pecking.

It was hypothesized that subjects in the experimental condition would have a greater number of LL choices compared to the control condition because they would be "distracted" from pecking the red light long enough for the green light to appear.

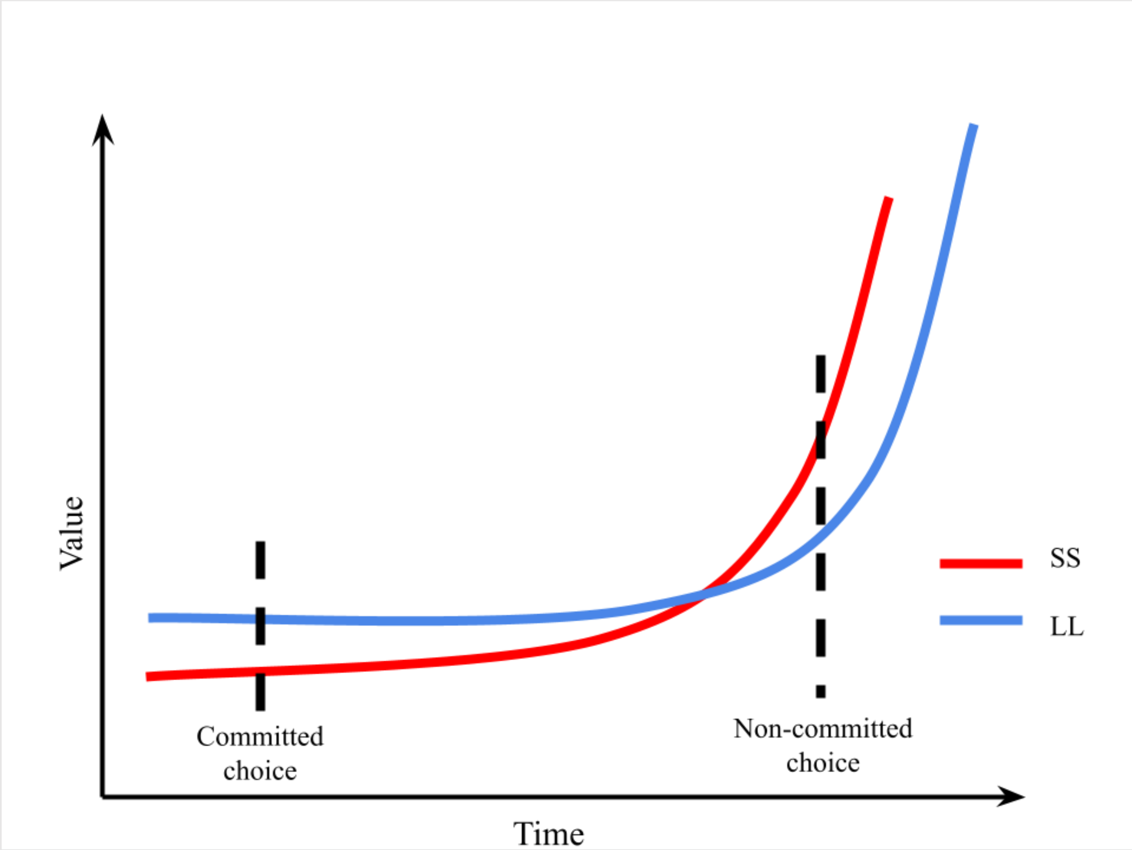

Figure 4.1 Differential Value in the Commitment Procedure Over Time
Two hyperbolic functions, one representing the value of the SS alternative and the other representing the value of the LL alternative. When a choice is made early (a committed choice), the subjective value of the LL alternative is greater than if the choice were made without the delay (a non-committed choice). Adapted from "Early commitment facilitates optimal choice by pigeons" by T. R. Zentall, J. P. Case, & J. R. Berry, 2017, *Psychonomic Bulletin Review*, *24*, 958.

4.2 Methods

4.2.1 Subjects

Twelve different pigeons similar to those described in Experiments 1 and 2 were used.

4.2.2 Apparatus

The same apparatus as previously described was employed in the present experiment.

4.2.3 Training Procedure

The difference between the delay procedure outlined in Experiments 1 and 2 and that used in the present experiment was the introduction of an additional constant delay between choice and reinforcement. The delay was 5 s long and present on all trials for both groups. After the subject pecked at either the red or the green stimulus, the stimulus remained on for 5 s before producing the appropriate number of pellets, 1 pellet for a peck to red and 5 pellets for a peck to green. That is, there were two separate types of delays in this experiment — the first (the red duration) refers to the duration the red key was illuminated prior to changing to the green key, and the second (the delay of reinforcement) was a constant 5 s immediately following a peck to either the red or the green light before reinforcement was delivered. Training consisted of 18 sessions of 64 trials. Sessions were completed 6 days a week.

With the introduction of the constant 5 s delay between choice and reinforcement, the duration for which the red key remained illuminated was lengthened from 0.5 s to 4 s. This duration is about twice as long as those employed for subjects in Experiments 1 and 2, who received appropriate reinforcement immediately following pecking either the SS or LL stimulus.

4.2.4 Testing Procedure

Pigeons were assigned to groups counterbalanced for the number of green choices in the sessions prior to testing using the method described in Experiment 2.

The red key was illuminated on either the left or right key at the beginning of each trial before changing to green after 4 s; if it was pecked before the 4 s had elapsed, it produced 1 pellet of reinforcement after a constant 5 s delay during which the red key remained illuminated and then terminated the current trial. After 4 s without a peck, the red light changed to green and a peck to the green light produced 5 pellets of reinforcement after a constant 5 s delay during which the green key remained illuminated. The green light remained on until it was pecked.

For subjects in the experimental group, a white triangle projected on a black background appeared on the other key at the same time as the red light (e.g., if the red key was presented on the right, the distractor key appeared on the left and vice versa). The white triangle remained illuminated until either the red or the green light had been pecked. Pecks to the distractor key were recorded but did not have a programmed effect.

For subjects assigned to the control condition, testing trials were similar to those in the experimental group, except that the white triangle did not appear on the other key. After 4 sessions of testing, the duration of the red light was increased from 4 s to 6 s, and after 3 sessions at 6 s, increased from 6 s to 10 s for an additional 3 sessions. Testing sessions consisted of 64 trials and were completed 6 days a week.

4.3 Results

Prior to testing, there was no significant difference between the experimental (M = 48.54, SD = 11.83) and control (M = 48.35, SD = 11.71) groups, $t(5) = 0.04$, $p = 0.97$. A 2x3 mixed-factor ANOVA was conducted to assess the main effect of group (control or experimental) and red light duration (4 s, 6 s, and 10 s), as well as the interaction between those main effects. The main effect of group was not significant, $F(1, 10) = 0.38$, $p = 0.55$; however, the main effect of red light duration was significant with a large effect size, $F(2, 20) = 41.00$, $p < 0.01$, $\eta_p^2 = 0.80$. The longer the red light was on, the less often the pigeons waited for the green light to appear. In addition, the interaction of red light duration and group was not significant, $F(2, 20) = 0.21$, $p = 0.82$.

A one-way repeated measures ANOVA was conducted to analyze the difference in the number of distractor pecks among the three different red duration blocks of testing sessions. The number of pecks to the distractor during sessions in which the red key was illuminated for 4 s ($M = 9.63$, $SD = 18.19$), 6 s ($M = 3.00$, $SD = 4.84$), and 10 s ($M = 14.89$, $SD = 25.98$) did not differ significantly as a result of the red duration, $F(2, 10) = 0.55$, $p = 0.59$. The results of Experiment 3 appear in Figure 4.2.

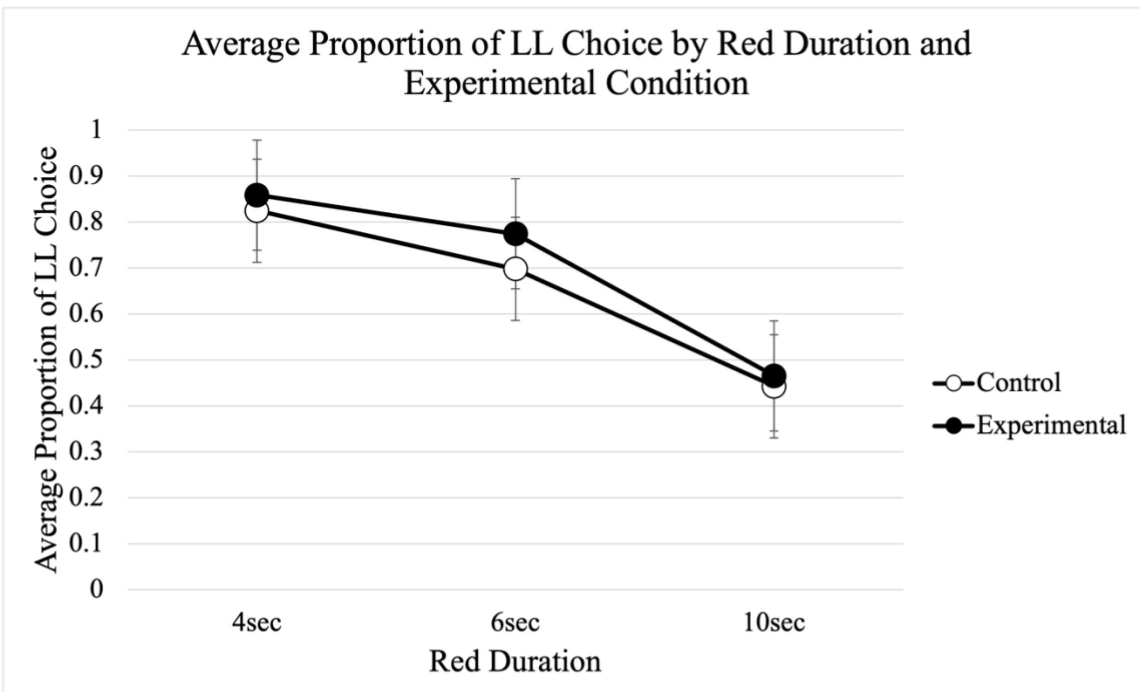

Figure 4.2 Results of Experiment 3
The proportion of net LL choices averaged over sessions as a function of the duration of the red light for the experimental and control groups. The baseline number of green choices, averaged over both groups, appears as a dashed line. Error bars represent the standard error.

The addition of the 5 s delay of reinforcement for pecks to the red and the green lights allowed the pigeons in Experiment 3 to wait up to 10 s for the green light to appear. This was substantially longer than the pigeons waited in Experiments 1 and 2.

4.4 Discussion

The results of Experiment 3 suggest that the presence or absence of a distractor key did not play a significant role in the number of net green choices made in the experiment. The significant main effect of red duration is to be expected — as seen in Figure 4.2 above, the net number of green choices decreased as the red key duration increased, suggesting that as the subjects were required to wait longer for the green stimulus to appear, they chose the red key regardless of whether the distractor stimulus was present or not.

One of the key differences of this experiment compared to the previous two was the introduction of the 5 s delay of reinforcement. The results of Experiment 3 provide further evidence for the efficacy of this delay of reinforcement. Greater experience with the delay training procedure alone did not significantly increase the number of LL choices, as shown in Experiments 2 and 3; however, pigeons were able to wait longer for the LL alternative to appear with the help of a constant 5 s delay of reinforcement. This is consistent with previous research that suggests introducing a constant delay of reinforcement can reduce impulsivity in pigeons (Zentall, 2020; Zentall et al., 2017; Zentall & Raley, 2019).

This finding may be important to bear in mind when considering the successive delay-discounting task, as it translates the hyperbolic function of delay-discounting to the right by the length of the duration between choice and reinforcement, thus making the optimal choice more subjectively valuable in the present compared to the suboptimal choice (see Figure 4.1). If the ultimate goal of a situation is to decrease overall impulsivity, the insertion of a constant delay prior to reinforcement may be a useful strategy. However, the efficacy of a distractor stimulus in coordination with this constant delay to decrease impulsivity has yet to be seen.

This may suggest that the methods in which pigeons were trained to interact with the distractor stimuli in the context of a successive delay-discounting task have not been effective. It is possible that adjusting the procedure by which subjects are trained to interact with each stimulus (SS, LL, and distractor) may play a role in how distractor stimuli are employed to self-regulate impulsive behavior.

CHAPTER 5. EXPERIMENT 4

5.1 Introduction

Given the results from the previous three experiments, it would appear as though the distractor key has little impact on increasing “self-control” in pigeons. However, the procedure employed previously was different from the procedure described by Grosch and Neuringer (1981) in that, in the present experiments, a separate LL stimulus was introduced. Here, a peck to the LL stimulus was required to receive the larger magnitude of reinforcement and progress to the next trial, whereas Grosch and Neuringer (1981) provided LL reinforcement at the offset of the SS stimulus. It is possible that in the absence of a peck to the green key, there is increased discriminability between the two outcomes; the SS reinforcement requires a peck, whereas the LL reinforcement does not. Additionally, pecks to the distractor key may have been reinforced adventitiously on a fixed-interval schedule directly corresponding to the schedule given to the red SS stimulus; this would generate a greater proportion of pecks on the distractor key and therefore increase the proportion of LL reinforcements, even if the distractor key was not truly "distracting" the subject from pecking the SS stimulus.

Following the results of the previous three experiments as well as Grosch and Neuringer's (1981) experiment, it was hypothesized that subjects in the group that received LL reinforcement immediately following the offset of the SS stimulus would have a greater number of LL reinforcements compared to subjects that were required to make a response to a separate LL stimulus.

5.2 Methods

5.2.1 Subjects

Twelve of the pigeons used in the previous three experiments were randomly selected to participate in this experiment.

5.2.2 Apparatus

The same apparatus as previously described was employed in the present experiment.

5.2.3 Training Procedure

A modified delay training procedure was implemented for all subjects. Instead of the LL stimulus following the offset of the SS stimulus as in previous experiments, all subjects received 5 pellets of reinforcement following the offset of the SS stimulus without a peck. If they pecked the red key while it was illuminated, they received 1 pellet of reinforcement. The duration that the SS stimulus was lit was gradually lengthened from 1 s to 4 s over 18 sessions. Each session comprised of 64 trials and sessions were conducted 6 days a week.

Pigeons were assigned in a counterbalanced manner to either the no green key group or the green key group, prior to the introduction of the green key, based on the average proportion of LL reinforcements received. Following the 18 sessions of training with the red key, subjects assigned to the green key group, received the red light for 4 s and without a peck to the SS stimulus, the red light changed to green, which remained lit until it was pecked. Once pecked, the LL stimulus produced 5 pellets of reinforcement. This training was provided to accustom the pigeons in the green key group to the green key event. These pigeons received 4 sessions with this procedure, where each session consisted of 64 trials. Subjects assigned to the no green key group continued to receive an additional 4 sessions of training with the red stimulus alone, followed by LL reinforcement as previously described.

5.2.4 Testing Procedure

All subjects were tested daily for 6 sessions. Each session consisted of 64 trials, half of which contained the distractor stimulus (a black numeral 4 projected on a white background) on the other side key (e.g., if the red key was presented on the right, the distractor appeared on the left and vice versa). The distractor appeared at the same time as the SS stimulus and remained on as long as there was a stimulus on the other key. Pecks to the distractor key were recorded but did not have a programmed effect.

5.2.4.1 No Green Key Group

For this group, half of the trials in a session were the same as previously described for the training procedure without the green key. That is, the red SS stimulus would remain on for 4 s or until pecked; it would produce 1 pellet if pecked before the 4 s and 5 pellets after it turned off without a peck. The other half of the trials were the same with the inclusion of the distractor stimulus on the other key that appeared and disappeared at the same time as the SS stimulus.

5.2.4.2 Green Key Group

For this group, half of the trials in a session were the same as previously described for the training procedure with the green key. That is, the red SS stimulus would remain on for 4 s or until pecked; if 4 s had elapsed without a peck, the green LL stimulus would replace it and remain lit until pecked. If the pigeon pecked the red SS stimulus, it would receive 1 pellet and if it pecked the green LL stimulus, it would receive 5 pellets. The other half of the trials were the same with the inclusion of the distractor stimulus on the other key that appeared at the same time as the SS stimulus and disappeared when the subject pecked either the SS or LL stimulus.

5.3 Results

Prior to testing, there was no significant difference in the number of times the red key was pecked between the green key (M = 22.17, SD = 16.82) and no green key (M = 25.42, SD = 20.05) groups, $t(5) = 0.64$, $p = 0.55$. Using the testing data, a 2x2x6 mixed-factor ANOVA was conducted to assess the main effects of group (green key or no green key), distractor presence (present or absent), and session (1-6). The main effect of group was significant with a moderate effect size, $F(1, 10) = 7.78$, $p = 0.02$, $\eta_p^2 = 0.44$. The main effect of distractor presence was also significant with a moderately large effect size, $F(1, 10) = 16.77$, $p = 0.02$, $\eta_p^2 = 0.63$. The main effect of session was significant with a moderate effect size, $F(1, 10) = 6.61$, $p < 0.01$, $\eta_p^2 = 0.40$. The three two-way interactions were not statistically significant; however, the three-way interaction was significant with a moderately small effect size, $F(5, 50) = 3.01$, $p = 0.02$, $\eta_p^2 = 0.23$. Upon closer inspection of the difference between distractor-present vs. distractor-absent trials between the green key group and the no green key group, there was a significant distractor effect with a moderately large effect size for the green key group, $F(1, 5) = 10.69$, $p = 0.02$, $\eta_p^2 = 0.68$, but the distractor effect was not statistically significant for the no green key group, $F(1, 5) = 6.08$, $p = 0.06$. The results of Experiment 4 appear in Figure 5.1.

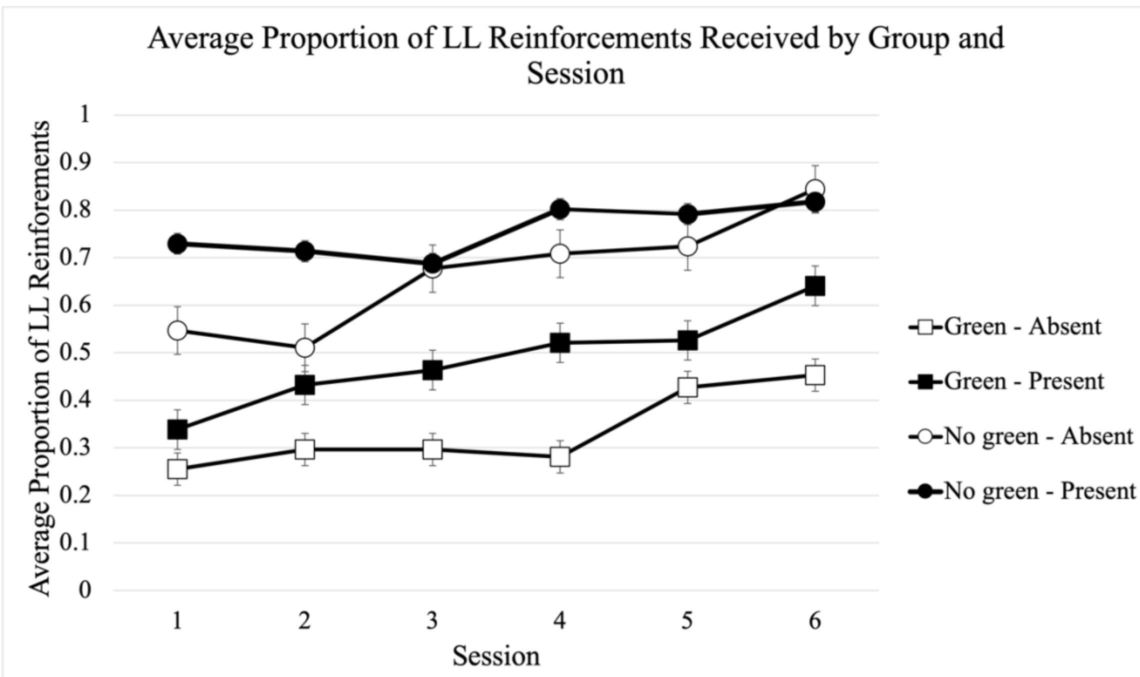

Figure 5.1 Results of Experiment 4
The proportion of LL reinforcements received plotted over all 6 testing sessions by group (green key or no green key) and distractor presence (present or absent). Error bars represent the standard error.

Interestingly, there was a significant difference between the number of distractor pecks between the green key group ($M = 109.78$, $SD = 74.93$) and the no green key group

(M = 37.28, SD = 20.69), $t(5) = 3.05$, $p = 0.03$. This indicates that subjects in the green key group pecked the distractor significantly more than subjects in the no green key group. It should be noted, however, that this difference may be due to a novelty effect for some birds, as the number of distractor pecks for the green key group made on the first session was an average of 268.83 pecks (SD = 210.45) that quickly dropped to an average of 148.33 (SD = 155.40) by the second session. Overall, average pecks made to the distractor by the green key group appeared to decrease over time whereas the subjects in the no green key group had a relatively consistent number of average pecks to the distractor over sessions (see Figure 5.2).

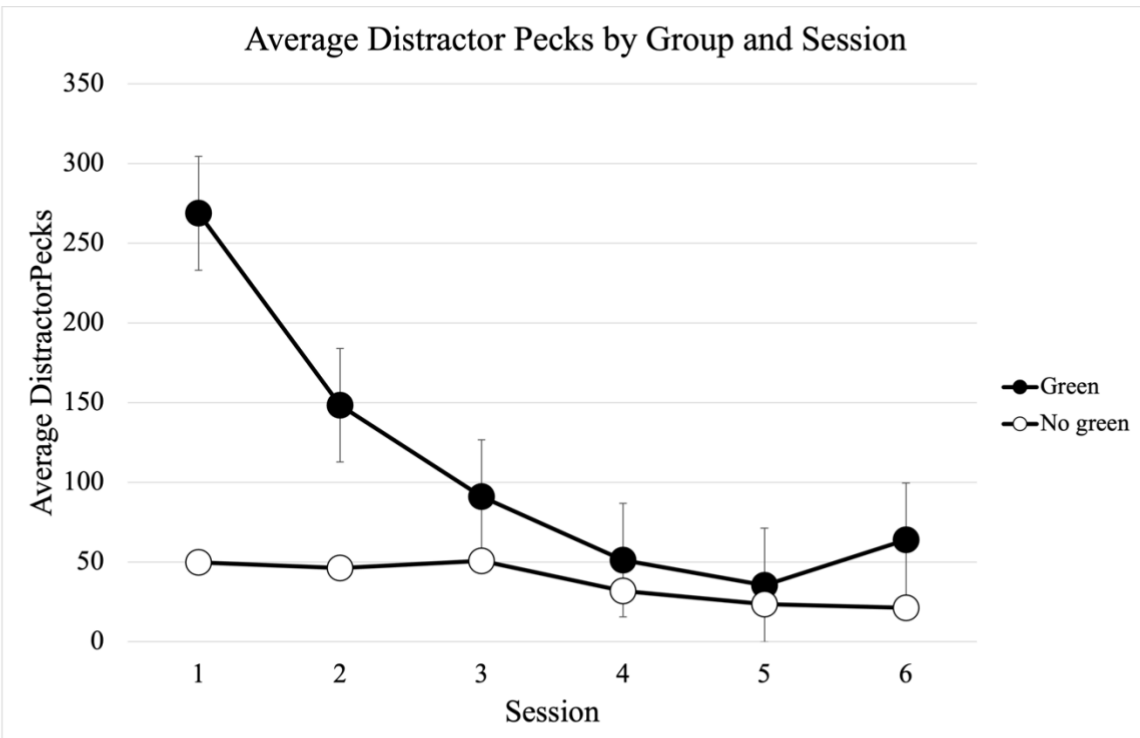

Figure 5.2 Distractor Pecks in Experiment 4
The average number of pecks to the distractor stimulus plotted over all 6 testing sessions by group (green key or no green key). Error bars represent the standard error.

Together, these results suggest that (1) the no green key group received a significantly larger number of LL reinforcements compared to the green key group, (2) trials containing the distractor key were significantly more likely to result in an LL reinforcement for subjects in the green key group, and (3) the proportion of LL reinforcements significantly increased with greater testing. It would appear that the distractor played a smaller role in the performance of the no green key group compared to the green key group.

5.4 Discussion

The results of Experiment 4 suggest that introducing a separate LL stimulus that requires a response to receive LL reinforcement may have contributed to the negative results observed in the previous three experiments. When pigeons only had to wait for the offset of the red key prior to receiving the LL reinforcement, they were able to resist pecking the SS stimulus significantly more often than pigeons that were required to peck the green key. Additionally, in contrast to the results observed in the previous three experiments, there was a significant distractor effect observed for subjects in the green key group.

One important result of this experiment is the fact that subjects in the no green key group received a significantly greater proportion of LL reinforcements than those in the green key group. This may be due to the fact that the no green key group did not have to peck a separate stimulus in order to receive LL reinforcement. Subjects in the green key group may have pecked too early in anticipation of the LL stimulus and inadvertently pecked the red SS stimulus, thus precluding them from receiving LL reinforcement. Since pigeons in the no green key group did not have to peck to receive the LL(as there was no stimulus that required them to peck at all during any given testing session), it is not surprising that subjects in the no green key group received a greater proportion of LL reinforcements.

Contrary to the results of the previous three experiments, a significant distractor effect was observed for the green key group, suggesting that trials on which the distractor was present, subjects received a greater proportion of LL reinforcements by not pecking the SS stimulus. This is a surprising finding given that there was no reliable distractor effect observed in the previous three experiments when a similar procedure was used (i.e., they had to suppress pecking the SS stimulus *and* peck a separate LL stimulus prior to receiving LL reinforcement). This observed distractor effect may be due to the difference in training the green key group received compared to training procedures in the previous three experiments. It is possible that training subjects to wait for the offset of the SS stimulus prior to receiving LL reinforcement is key in allowing them to wait in the presence of the SS stimulus for longer periods of time. Additionally, this training procedure may have given subjects the opportunity to treat the distractor stimulus as a higher-ordered conditioned reinforcer. That is, pecking the distractor stimulus kept the pigeons from pecking the SS stimulus and allowed the LL stimulus to appear, and pecking the LL stimulus gave the subject LL reinforcement – therefore, an association between the distractor stimulus and the LL reinforcement was formed.

This may also explain the greater difference in the proportion of LL reinforcements received on distractor-present vs. distractor-absent trials for the green key group compared to the no green key group, for whom LL reinforcement between distractor-present vs. distractor-absent trials converged over sessions (see Figure 5.1). Since subjects in the no green key group were never required to peck to receive LL reinforcement, pigeons may have learned to not peck regardless of trial type. Subjects in the green key group received training where they were required to peck the green LL stimulus to receive LL reinforcement prior to the introduction of the distractor stimulus, which may have made them more willing to peck the distractor stimulus before they learned that it had no programmed effect.

In the previous three experiments, there was no reliable distractor effect observed (aside from one in Experiment 1 that may have been solely due to a novelty effect). However, in Experiment 4, the green key group did have a consistent distractor effect – subjects received a greater proportion of LL reinforcements on distractor-present trials than they did on distractor-absent trials for all 6 testing sessions. This may be due in part to the modification in the training procedure employed for this study. Subjects in the green key group were initially trained to wait for the offset of the red SS stimulus in order to receive LL reinforcement, prior to the introduction of the green key. After they were familiar with this procedure at a stable red duration of 4 s, the introduction of the green key required them to peck at a separate LL stimulus in order to receive LL reinforcement. This may have encouraged them to peck new stimuli in order to receive reinforcement, which may explain why there was a significantly greater average number of pecks to the distractor made by the green key group compared to the no green key group and may also explain the sustained distractor effect in the green key group observed over all 6 sessions.

Contrary to hypothesis, as distractor pecks decreased for subjects in the green key group over sessions (see Figure 5.2), the average proportion of LL reinforcements received increased over sessions (see Figure 5.1). This would suggest that there may be two simultaneous learning processes occurring for subjects in this group – while the distractor stimulus was novel, subjects pecked at it repeatedly over the session, even after the non-distractor key had changed from red to green. As the pigeons learned that the distractor stimulus would not directly provide them with reinforcement, the number of pecks declined over sessions. While responses to the distractor stimulus were undergoing extinction, pigeons in the green key group may have learned the timing contingency placed on the red SS stimulus changing to the green LL stimulus better than they had during training, leading to greater stimulus control by the green key. If these two processes were occurring simultaneously, this would explain the significant decrease in responses to the distractor key over the 6 testing sessions while the proportion of LL reinforcements received increased over sessions. Although pecks to the distractor key declined over testing, the effect of the distractor key on delaying pecks to the reinforcement key remained. It may be that the pigeons continued to be “distracted” by the distractor key without having to peck it.

The significant three-way interaction effect is likely primarily due to the narrowing of LL choices in the no green key group between distractor-present vs. distractor-absent trials, as seen in Figure 5.1. Subjects in the no green key group had a greater proportion of LL reinforcements for distractor-present trials on the first two sessions, but that difference quickly dissipated over the remaining four sessions. This convergence of the effect of the distractor key for the no green key group may have been partly due to a ceiling effect for that group or that the no green key group learned to wait better even on distractor-absent trials.

CHAPTER 6. GENERAL DISCUSSION

6.1 Nature of Distraction

The four experiments described all attempted to test the use of a distractor key to which responses had no programed consequence in a successive delay-discounting task. The effect of a distractor stimulus to decrease impulsivity, like Grosch and Neuringer (1981) found, is not as clear-cut as originally envisioned.

There is evidence to suggest that human and nonhuman animals alike are capable of employing distractors to obtain a more-preferred reinforcer (Evans & Beran, 2007; Mischel et al., 1972; Newquist et al., 2012; Williams & Williams, 1969). The present study used a distractor stimulus presented on a pecking key as it was easy to measure interaction with the key through the number of cumulative pecks over the course of the session; however, few subjects in Experiments 1-3 consistently pecked at the distractor key, and those that did peck at it in Experiment 4 were likely doing so as a result of their training involving the green key after their initial training with the red key alone. That being said, the number of pecks subjects in the green key group made to the distractor were likely made in extinction as they learned that it did not directly provide reinforcement — and yet a significant distractor effect was observed for this group.

Any stimulus could theoretically be a distractor, even if it does not require a response. Though responses to other stimuli could not be measured, the pigeons may have pecked (or air-pecked without making contact) at other parts of the operant chamber, such as the house light, different panels of the chamber, the floor, etc. Additionally, even observing the distractor key may have been distracting long enough for the non-distractor key to switch from the red SS stimulus to the green LL stimulus.

In earlier research with chimpanzees participating in the accumulation task (Evans & Beran, 2007) or children attempting to avoid a salient food reinforcer (Mischel et al., 1972; Newquist et al., 2012), the toys that were used as distractors and were found to reduce impulsive behavior were very likely inherently reinforcing. Additionally, Mischel et al. (1972) suggest that certain thought patterns (thinking of "fun things") served to effectively distract from food reinforcers, while non-reinforcing thought patterns (thinking of "sad things") did not. Thus, it is possible that toys may serve as alternative primary reinforcers in a way that the distractor stimuli used in the present experiments were not. Associating the distractor directly with reinforcement as in the no green key condition in Experiment 4 may increase interaction with the distractor stimulus and therefore increase the proportion of LL reinforcements subjects receive.

6.2 Influence of Delay-Discounting Task

Aside from the effects seen in Experiment 4, which were likely due to modifying the training procedure, the type of delay-discounting task employed in this study may have contributed to the different effects due to the distractor stimulus. The successive delay-discounting task has not been widely used as most studies employ the simultaneous delay-discounting task and, as such, it is possible that there is an inherent difference between the two tasks in how pigeons discount LL alternatives. The successive delay-discounting task makes use of a modified go/no-go procedure which, for pigeons, may not be the best method of assessing "self-control". In a traditional go/no-go procedure, responses may be biased towards "going" or pecking. If a subject pecks on a "go" trial, it will receive reinforcement that it would otherwise miss if it mistook the trial as a "no-go". Suppressing responding during "no-go" trials may be more difficult than pecking

(McMillan et al., 2015). Even in negative automaintenance where pigeons are fed on a fixed time schedule, conditional on not pecking an illuminated key, pigeons will learn to peck an alternative key, even when that key does not directly provide reinforcement (Williams & Williams, 1969). Taken together, it may be much more difficult than originally anticipated for pigeons to wait in the presence of the SS stimulus, even with a distractor key available as an outlet for responding. As such, the length of time the pigeons are able to wait for the SS stimulus to turn off is markedly shorter than the duration they can withstand in a typical simultaneous delay-discounting task. Other types of delay-discounting tasks, such as the accumulation task or the rotating-tray task (Beran et al., 2016; Bramlett et al., 2012; Evans & Beran, 2007) for example, may prove to be better procedures to see a more consistent distractor effect in pigeons.

When the methods employed by Grosch and Neuringer (1981) were replicated with modifications in Experiment 4, the distractor effect was observed, but only for subjects in the green key group. The distractor effect was not significant for subjects in the no green key group that were analogous to the pigeons used in Grosch's and Neuringer's (1981) study. This may be due to the fact that the distractor stimulus was unnecessary to receive LL reinforcement, and pecks were not sufficiently reinforced with SS reinforcement during training, prior to the introduction of the distractor stimulus. This suggests that training with a separate LL stimulus that required a peck to receive reinforcement may have been more detrimental to pigeons' ability to wait for LL reinforcement than originally hypothesized. In Experiment 4, subjects in the green key group had two phases of training: one in which they received LL reinforcement following the offset of the SS stimulus and one in which they received it after pecking the green LL stimulus. This training procedure may have primed the pigeons to wait longer for the offset of the SS stimulus. A significant positive effect due to the distractor was present in the green key group, even though subjects in the green key group tended to receive proportionally fewer LL reinforcements compared to the no green key group.

By including a separate LL stimulus that required a response prior to receiving the larger reinforcement, the goal of the current study was to control for results that may have been due to adventitious reinforcement of responding to the distractor stimulus. The significant distractor effect observed in the green key group in Experiment 4 was likely due to the modified training procedure. Instead of offering the LL stimulus that required a response to receive appropriate reinforcement, training with LL reinforcement following the offset of the SS stimulus may have encouraged the pigeons to wait for a greater proportion of trials, as evidenced by the comparatively longer duration pigeons were willing to resist pecking the SS stimulus in Experiment 4 (4 s) compared to Experiments 1 and 2 (2 s and 1.5 s, respectively).

6.3 Broader Implications

This research may have far-reaching implications outside of how pigeons make decisions. The present experiments demonstrate that distractors may sometimes be an effective preventative measure for decreasing impulsive behavior. Drug-taking behavior in humans can be considered through a modified delay-discounting framework (Kollins, 2003; Mitchell, 2017). When considering the behavioral (rather than neurobiological) aspects of drug addiction, the impulsive option is to ingest the drug to receive a near-immediate, though short-lived l high; the self-controlled option is to resist taking the drug to avoid the negative consequences associated with the drug (e.g., physiological withdrawal effects, losing money, endangering one's life and health, etc.). If an individual is unable to resist taking the drug, providing some sort of distraction when presented with the option to ingest or not ingest the drug may be effective under certain circumstances. If the drug-taking behavior began innocuously in that one was unaware of the consequences, and later, as the addiction progressed, the individual became aware of the consequences, under the right conditions, it may be beneficial to provide some type of distractor in the environment to prevent or reduce the drug-taking behavior.

Outside of substance abuse, this research may also be applicable in instances where impulsive behavior can otherwise be detrimental to performance academically, personally, and professionally. Given some situation where prior commitment is required to behave in a self-controlled manner with the option to behave otherwise, having a sufficiently salient, though transient, distractor present may be useful in decreasing impulsive behavior for some time.

It is also important to consider those situations where the SS and LL choices are not involving positive reinforcers, but rather positive punishers. Perrin and Neef (2012), for example, examined how autistic elementary schoolchildren would respond to a delay-discounting task in which they were required to solve math equations. In this scenario, the impulsive option would be to delay a more aversive event (i.e., solving a difficult equation, or an LL alternative) rather than accepting a less aversive event immediately (i.e., solving an easy equation, or an SS alternative). Here, distractors may actually be detrimental to behaving in a self-controlled manner, as the optimal choice would be to perform the behavior as quickly as possible. This scenario can be extended to other events where procrastination is detrimental to performance, including those where not performing a behavior leads to failing grades, fines, deteriorating health, etc. In these instances, being distracted would likely increase impulsive behavior and thus other methods of increasing self-control should be considered to decrease suboptimal behavior.

6.4 Limitations to the Present Research and Future Directions

The experiments presented here are not without flaws. In the future, research considering the efficacy of using non-reinforced distractors to increase "self-control" may consider collecting trial-by-trial data on the number of distractor pecks made per trial. It may be important to observe the different rates at which pigeons respond to the distractor stimulus during the trials on which it was presented throughout a session. This is especially useful in determining how pigeons interact with the distractor over the course of the session (e.g., subjects may make a large number of responses on relatively few trials per session or their rate of responding to the distractor may be relatively consistent throughout the session). Knowing this information will further elucidate the learning processes occurring in the successive delay-discounting task (especially as observed in Experiment 4).

Additionally, collecting data on the response latency to a particular non-distractor stimulus may be of interest in assessing the effectiveness of the distractor stimulus. For example, if the red duration was set at 4 s and the pigeon was able to wait 3 s before it pecked at the SS stimulus, this may provide some evidence that the distractor is somewhat effective at decreasing suboptimal behavior; however, if the pigeon pecked immediately after the onset of the SS stimulus, this may suggest that it had learned to peck at whatever stimulus was presented without considering the LL alternative as a consequence. Future research may consider using response latency in the presence of a distractor stimulus within a successive delay-discounting task to predict impulsive behavior.

Given that any stimulus within the operant chamber may be considered a distractor, even without a measured response, it may be difficult to determine if pigeons were distracted from the SS stimulus or not if they did not peck at the distractor stimulus. It is possible that subjects made use of a different aspect of the experimental chamber to suppress responses to the SS stimulus. Future studies should consider using a more general stimulus than a response key (e.g., a tone or a house light) as a distractor, including a photo beam in front of the response keys to measure air-pecks that do not fully make contact with the response keys, or including a camera within the operant chamber to quantitatively measure other responses that are not directed at the choice keys.

The present experiments all used magnitude of reinforcement in a successive delay-discounting task to assess circumstances under which pigeons are willing to wait in anticipation of a better reinforcer available later over a poorer one available sooner. Future experiments may consider using quality of reinforcer — e.g., one type of grain that is more-preferred over another type of grain, as used by Grosch and Neuringer (1981) — or probability of reinforcement (i.e., responses to the SS stimulus are reinforced less often than responses to the LL stimulus). This research may further elucidate how pigeons make decisions that impact future earnings under different circumstances.

Additionally, future research may focus on how humans make use of non-reinforced distractors in their environment to prevent making an impulsive choice. As aforementioned, this research may be beneficial for treating substance abuse or improving academic and professional development. Self-control has been linked to a number of constructs that improve functioning in society — determining methods by which one can increase the expression of self-control may improve emotional affect, decrease aggression, and decrease substance use (DeWall et al., 2011; DeWall et al., 2012; Kollins, 2003; Mitchell, 2017). Finding ways to increase self-control behavior can incur numerous benefits by better understanding the nature of impulsivity and how methods of increasing self-control in pigeons can be implemented in humans to improve anthropocentric society.

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