QUANTITIES OF REINFORCEMENT AND ITS EFFECT ON RESURGENCE IN PIGEONS

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CERTIFICATION OF APPROVAL

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DEDICATION

This thesis is dedicated to the children and adults who, though relentless, will never have the opportunity to achieve their dreams.

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I am thankful for my best friend Rebekah Maloy, for always being ready with words of encouragement when I was disheartened, and reminding me that I was worthy when I felt undeserving. You gave me confidence, and helped me to find the best in myself and for that I am eternally grateful.

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ABSTRACT

Four experimentally naïve King Hubbard pigeons were used in order to determine the effect that quantities of reinforcement would have on resurgence. An ABCDBC design was implemented, and the pigeons were provided reinforcement in the form of food pellets for 3-sec or 6-sec for either left or right key pecks. In phase 1, B1 (left or right key pecks) was reinforced for either 3-sec or 6-sec. In phase 2, B1 was placed on extinction and B2 (pecks to the opposite key) was reinforced for 3-sec for all pigeons. In phase 3, B1 and B2 were placed on extinction. In phase 4, pigeons who were initially reinforced for 3-sec for B1 were reinforced for 6-sec and vice verse. Phase 5 was identical to phase 2; B1 was on extinction and B2 was reinforced for 3-sec for all pigeons. Phase 6 was identical to phase 3; B1 and B2 were placed on extinction. Resurgence was observed in both extinction phases, evidenced by higher levels of B1 responding in the respective resurgence phase compared to the previous phase where B1 was on extinction. After comparing both extinction phases, it was determined that quantities of reinforcement did not have an effect on resurgence.

Keywords: resurgence, quantities, reinforcement

INTRODUCTION/LITERATURE REVIEW

Resurgence is the recovery of a previously reinforced behavior when a newly reinforced behavior is placed on extinction (Doughty & Oken, 2008). Producing resurgence in the experimental setting is accomplished in three phases. In phase1, the first behavior (B1) is shaped and reinforced. In phase 2, B1 is placed on extinction and an alternative behavior, behavior 2 (B2), is reinforced. Lastly in phase 3, B1 and B2 are placed on extinction. Resurgence occurs if levels of B1 emerge in higher levels relative to its levels at the end of phase 2 (Kestner, Redner, Watkins, & Poling, 2015). Marsteller and St. Peter (2014) describe the 3 phase procedure as "typical," as do Shahan and Sweeney (2011). However researchers such as Lieving and Lattal (2003, Exp 1) and Hoffman and Falcomata (2014) employed a period of extinction of B1 before B2 was reinforced.

Similar Types of Relapse Behavior

There are other phenomena similar to resurgence such as renewal, reinstatement, spontaneous recovery, and response induction or response generalization (Lattal & Pipkin, 2009, Kincaid, Lattal, & Spence, 2015). These occurrences, like resurgence, are evident when a previously extinguished behavior recurs. Renewal occurs when a context change (changes to the environmental stimuli) follows extinction with the result that the initial behavior occurs again. While renewal focuses on changes to the environment, resurgence encompasses changes to reinforcement parameters (Kincaid et al., 2015). Reinstatement occurs when the

reinforcer maintaining a behavior is delivered noncontingently, after extinction (Shahan & Sweeney, 2011). In spontaneous recovery, no other responses are systematically reinforced during the extinction of B1 (Lattal & Pipkin, 2009), but the original behavior trained increases after a period of nonreinforcement. Response induction or response generalization is a phenomenon where the behavior which emerges is similar in topography to the original response (Lattal & Pipkin, 2009).

Volkert, Lerman, Call, and Trosclair-Lasserre, (2009) claim that there are several reasons for treatment relapse, such as treatment integrity, lack of proper extinction of problem behavior, schedules of reinforcement, behavior change agents in the natural environment not understanding subjects prompts (Durand & Carr, 1991), not reinforcing every instance of appropriate responses (Durand & Kishi, 1987), and inappropriate thinning (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000). These examples suggest the occurrence of extinction-induced resurgence.

Benefits to Studying Resurgence

Analyzing resurgence may provide insight to the causes of relapse following contingency management therapy (CM) (Schepers & Bouton, 2015). CM is a procedure used to treat different types of behavior, including but not limited to, drug abuse (Higgins, Silverman, & Heil, 2008) and alcohol abuse (Dougherty et al., 2014) in humans. Though CM has proved effective in drug and alcohol abuse (Alessi, Hanson, Wieners, & Petry, 2007; Higgins et al., 2008; Alessi & Petry, 2013), studies show that after the intervention is removed, the original behavior occurs again at high levels (McDonell et al., 2012). Therefore, it is evident that continued analysis of

resurgence is advantageous to understanding how to prevent these, and other types of behaviors, from resurging.

In addition to humans, resurgence has been observed and analyzed in a range of species and populations. Some of these include: pigeons (Lieving & Lattal, 2003; Doughty, da Silva, & Lattal, 2007; Kincaid et al., 2015), rats (Carey, 1953; Leitenberg, Rawson, & Bath, 1970; Reed & Morgan, 2006; Winterbauer & Bouton, 2010; Winterbauer & Bouton, 2012; Kestner et al., 2015; Shahan, Craig, & Sweeney, 2015; Shepers & Bouton, 2015), and children with disabilities and problem behavior (Volkert et al., 2009; Hoffman & Falcomata, 2014; Marsteler & St. Peter, 2014).

Examples of Resurgence

To reiterate, resurgence is produced during the final phase of a three phase procedure where (1) B1 is reinforced, (2) B1 is placed on extinction and B2 is reinforced, and (3) B1 and B2 are placed on extinction (Lattal & Pipkin, 2009). Occasionally researchers will include an extinction phase after phase 1 to completely extinguish B1 responding, prior to reinforcing B2 (Hoffman & Falcomata, 2014). When either of these criteria are met, and reinforcement schedules remain the same for B1 and B2 responding, this can be considered conventional resurgence. Hoffman and Falcomata (2014) evaluated the resurgence of mands using participants with autism and histories of problem behavior. Two mands were taught to the participants; card exchange and microswitch press. Four phases were used in the experiment; (1) FR1/extinction, (2) Extinction/Extinction, (3) FR1/extinction, and (4) Extinction/Extinction. In phase 1, Mand 1 (B1) produced 30s access to reinforcement.

In phase 2 (Extinction/Extinction), all behavior was placed on extinction. In phase 3 (FR 1/Extinction), Mand 2 (B2) was reinforced and B1 was placed on extinction. The final phase (Extinction/Extinction) was identical to phase 2. Results show that during phase 4, resurgence occurred in eight out of nine participants.

Lieving and Lattal (2003) used pigeons to test for resurgence. In experiment 1, phase 1, key pecking of the right key (B1) was placed on a VI 30s schedule until 20 sessions were complete and responses stabilized. Then, treadle pressing (B2) was reinforced on a VI 30s schedule and B1 was placed on extinction. In the final phase, B1 and B2 were placed on extinction. Results show that resurgence occurred for all pigeons.

In experiment 2, Lieving and Lattal (2003) wanted to identify whether resurgence is repeatable with the same response and participants. They accomplished this by replicating experiment 1 but added in another training session in which responding was re-established. Resurgence occurred in all extinction phases for three subjects, and half of the extinction phases for the other subject, demonstrating that resurgence is repeatable. Furthermore, there was no decrease in the amount of resurgence in the second exposure.

Volkert et al. (2009, Exp 1) set to determine if children with problem behavior (and w/ Autism or DD) would display resurgence. The experiment was an ABCABC reversal design; (A) baseline, (B) FCT and FCT maintenance, and (C) extinction. Baseline was identical to the functional analysis. During FCT, problem behavior was placed on extinction and alternative responses were reinforced with prompts. The

FCT maintenance phase was identical to the FCT condition, except no prompts were given. In the final phase, extinction, all behavior was placed on extinction. The data show resurgence was demonstrated with two of the three participants.

Winterbauer and Bouton (2010, Exp 1 & 2) demonstrated resurgence of lever pressing in 2 groups of rats; group R1 30 (Exp 1) and group R1 10 (Exp 2), using conventional methods. Both groups received the same reinforcement contingencies for B1 and B2 during the experiments. In both experiments, B1 was reinforced on an RI 30s schedule of reinforcement. In phase 2, B1 was placed on extinction and the rats received reinforcement for B2 relative to their group. In phase 3, B1 and B2 were placed on extinction. Results are typical of resurgence; high levels of B1 responding from R1 30 and R1 10 groups.

Winterbauer and Bouton's second experiment was almost identical to the first in this study, the major difference being in experiment 2, phase 1 consisted of an RI 10s rather than RI 30s schedule of reinforcement. This was done to determine if resurgence would be produced under a leaner schedule of reinforcement. In other words, group R1 30 received an increase in reinforcement for B2 compared to B1 responding in experiment 1, but received a decrease in reinforcement for B2 responding compared to B1 in experiment 2. Results were identical to experiment 1; resurgence occurred at the same levels for the both R1 30s and RI 10s groups.

The Effects of Punishment on Resurgence

Punishment has been used to decrease resurgence (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Kestner et al., 2015). Kestner et al. (2015) describe

ways in which to decrease resurgence; (1) reinforce B2 in a different context and (2) add punishment to the extinction procedure when B1 resurges. Kestner et al. (2015) utilized a punishment procedure to prevent resurgence in 10 male Sprague-Dawley rats. Four operant chambers, each with two retractable levers and an opening for food distribution, were used. In phase 1, rats were trained to lever press (B1) on a VI 30s schedule with a 3-sec changeover delay. In phase 2, left nose poking (B2) was reinforced on a VI 30s schedule with a 3-sec COD, and B1 was placed on extinction. The experimental group also received a foot shock for B1 response in this condition. The control group received no consequences for B1 responding. Finally the rats entered phase 3 in which all behavior was placed on extinction with no consequences. Results showed that rats in the experimental group (punishment) exhibited nearly zero occurrences of B1 responding in phase 2 and almost no B1 responding for duration of the experiment. Four of the five rats in the experimental group did not demonstrate resurgence in phase 3. However, four out of five rats in the control group did. Thus it can be determined that punishment is a successful method for preventing resurgence from occurring.

The Effects of NCR on Resurgence

Another parameter which has an effect on decreasing resurgence is noncontingent reinforcement (NCR) (Lieving & Lattal, 2003, Exp 3; Shahan & Sweeney, 2011; Marsteller & St. Peter, 2014; Shepers & Bouton, 2015, Exp 1), when compared to no change in reinforcement parameters. NCR is a time-based reinforcement delivery schedule, independent of responding (Wallace, Iwata, Hanley,

Thompson, & Roscoe, 2012). In the applied setting, NCR has been used when attempting to decrease problem behavior such as: self-injurious behavior (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Vollmer & Marcus, 1995; Roscoe, Iwata, & Goh, 1998), and aggression (Lalli, Casey, & Kates, 1997; Dupuis, Lerman, Tsami, & Shireman, 2015). Lieving and Lattal (2003, Exp 3) used NCR to determine its effect on resurgence when they implemented VT schedules of reinforcement. The purpose of experiment 3 was to determine if the response-reinforcer relation was responsible for an increase in B1 responding when both B1 & B2 are placed on extinction. After reinforcing key pecking (B1) in phase 1, and treadle pressing (B2) in phase 2 (with key pecking on extinction) on VI schedules of reinforcement, they placed B2 on a VT schedule of noncontingent reinforcement and tested for resurgence. Resurgence did not occur with the VI or VT schedules however, so a conventional extinction procedure was implemented. Resurgence occurred in six out of six extinction conditions. Rescorla and Skucy (1969) alleged that response-independent reinforcement is extinction, however Lieving and Lattal (2003) argue that, had they been the same, we would expect similar results. Noncontingent reinforcement during the resurgence phase did not produce resurgence of B1; B2 continued to occur. It was not until conventional resurgence was implemented did we see B1 resurge.

Marsteller and St. Peter (2014) set to evaluate the effects of NCR on resurgence using a fixed time (FT) reinforcement schedule. Five conditions were used; (1) baseline (2) DRA training (3) DRA (4) FT and (5) extinction. Participants

were children with problem behavior. During baseline (phase 1), each occurrence of problem behavior was reinforced on an FR 1 schedule. Then in phase 2 (DRA), problem behavior was placed on extinction and appropriate behavior was reinforced on an FR 1 schedule. During the FT phase, all reinforcers were delivered on an either an FT 1s or FT 2s schedule. During extinction (phase 3) no consequences or reinforcement delivery were provided. Results show that resurgence of the problem behavior occurred for all participants in at least one extinction session (the researchers examined the FT and extinction conditions as instances where resurgence could occur).

Schepers and Bouton (2015, Exp 1) demonstrated how NCR effects responding and resurgence. 32 rats were used in this experiment, and lever presses were the target responses. In phase 1, rats were reinforced on a VI 30s schedule for B1 responses. Then the rats entered phase 2 for eight sessions, and were randomly divided into four groups; VI 10s, reverse-thinning (an increasingly rich schedule going from VI 1200s to VI 10s), group VI 10s yoked, and group reverse-thinning yoked. The rats were reinforced for B2 responses based on their group. Phase 3 was one 30 minute session where all responding was placed on extinction. Results were typical of resurgence for the groups who received reinforcement contingent on responding. B2 responding was almost nonexistent for participants in the noncontingent groups during phase 3.

Winterbauer and Bouton (2010, Exp 3) used 24 rats to determine the effect of different reinforcement schedules on resurgence; one of which (Group FREE),

received reinforcement on a NCR schedule. In phase 1, rats were reinforced differently for lever pressing (B1). Group RSRG received reinforcement on an RI 30 schedule of reinforcement. Group FREE only received reinforcement for B1 when their counterpart member from Group RSRG received a pellet. Group X received no reinforcer. In phase 2, B1 was placed on extinction and all rats received reinforcement for B2 on a CRF schedule. This occurred for the first 10 lever presses, and then reinforcement was provided on an RI 10 schedule. In phase 3, all behavior was placed on extinction. Results show resurgence for all groups; most notably in group RSRG. Interestingly, Group X, who never received reinforcement for B1, engaged in increasing B1 responding while decreasing B2 responding during phase 3.

The Effects of Environmental Changes on Resurgence

Changes in the environment during reinforcement of B1 and B2 have shown to have an effect on resurgence (Mace et al., 2010, Kincaid et al., 2015). In a study by Mace et al. (2010), two adults exhibiting disruptive behavior were reinforced for B2 in a different room than B1. As a result, resurgence did not occur.

Kincaid et al. (2015) used a color changing response key to determine the effect of environmental changes during the resurgence phase. Pigeons were used as subjects. In phase 1, key pecking on both keys was reinforced on a concurrent VI 2min VI 2min schedule. In phase 2, Key A remained the same and Key B changed color. Reinforcement was delivered on a DRO 20s schedule in which reinforcement was delivered as long as no responses occurred on either key for 20 seconds. In phase 3, Key A remained the same and Key B changed back to original color, and all key

pecks were placed on extinction. Results show that resurgence of key pecks occurred during phase 3, with more responses occurring on Key B than Key A during the first session of this phase. Thus determining that changes to an exteroceptive stimulus results in more resurgence.

The Effects of Time Reinforcing B2 on Resurgence

Time is a variable that has been manipulated to determine its effect on resurgence (Leitenberg, Rawson, &Mulick, 1975). Leitenberg et al. (1975, Exp 4) were interested in determining the effect that time reinforcing an alternative behavior would have on resurgence. Rats were used as subjects and target responses were lever presses. In phase 1, B1 was reinforced on a VI 30s for 5 days. In phase 2, B1 was placed on extinction and the rats were randomly assigned to one of 4 groups; 0, 3, 9, or 27, and received reinforcement for B2 on a VI 30s schedule for the amount of days based on their group name. Then in phase 3, all behavior was placed on extinction. The results of this study showed that the longer B1 was on extinction and B2 was reinforced during the alternative reinforcement phase, the weaker the resurgence of B1 during the final extinction phase.

The Effects of Thinning Reinforcement/Intermittent Reinforcement on Resurgence

Winterbauer and Bouton (2012) devised three experiments in which they manipulated rate of reinforcement with thinning procedures to determine its effect on resurgence. Rats were used as subjects and lever presses were the target responses. In experiment 1, phase 1, rats were reinforced for B1 on a RI 30. In phase 2, rats were

separated into 3 groups: extinction (no reinforcement), resurge (B2 reinforced only on RI 20), and thinning (B2 reinforced on RI 20 and gradually thinned). In phase 3, all behavior was placed on extinction. Group thinning demonstrated a gradual increase of B1 responding as B2 was thinned during phase 2. In phase 3, group thinning's rate of B2 responding continued to decline, and B1 responding began to decrease as well. Thinning reinforcement schedules such as this can cause extinction-like conditions in which responding recurs due to a decrease in reinforcement availability, as we see in Winterbauer and Bouton (2012)'s experiment 2 and 3.

Experiment 2 of Winterbauer and Bouton (2012) was conducted to further examine the effects of thinning schedules of reinforcement on resurgence. Experiment 2 was almost identical to experiment 1, however B2 was reinforced differently: Group Resurge (RI 20), Group Stepped (RI 20, then increased 20s increments every 15 minutes of each subsequent session), and Group Gradual (RI 20 then increased by .011 increments, in order to achieve an increase of 20s by the end of each session; the final session ended with RI 120). Group Stepped and Group Gradual resulted in the same reinforcement schedule by the end of each session (session 2, RI 20 to RI 40; session 3, RI 40 to RI 60; session 4, RI 60 to RI 80; session 5, RI 80 to RI 100; and session 6 RI 100 to RI 120), however one group had a much more gradual increment (gradual group) than the other (stepped group).The researchers were attempting to prevent early resurgence by avoiding abrupt thinning of reinforcement, however they were unsuccessful. Results show that Group Stepped

and Group Gradual produced similar results as Group Thinning in experiment 1; early resurgence occurred in phase 2 of the experiment.

Winterbauer and Bouton (2012, Exp 3) also reinforced B2 differently in phase 2 with different groups: Group Random Resurgence (RI 20; same as Group Resurge in Exp 2), Group Fixed Resurgence (FI 20s), Group Random Thinning (same as Group Gradual in Exp 2, but in the final eight sessions, the reinforcement schedule was kept at RI 120), and Group Fixed Thinning (same as Group Random Thinning, but ending with FI 120). Results show Group Random Thinning and Group Fixed Thinning to both have early resurgence in phase 2 with little resurgence in phase 3. Both random resurgence and fixed resurgence groups showed high levels of resurgence following the initial extinction session in phase 3.

Lieving and Lattal (2003, Exp 4), used fairly lean reinforcement schedules to test its effects on resurgence. In phase 1, B1 (key pecking) was reinforced on a VI 30s schedule. In phase 2, B1 was placed on extinction and B2 (treadle pressing) was reinforced on a VI 30s. In phase 3, they continued to place B1 on extinction and increased the VI 30s schedule for B2 to a VI 360s schedule. Then they included a final phase where they placed both behaviors on extinction to compare rates of B1 during a lean schedule of reinforcement to the resurgence phase. Results show that resurgence occurred for 2 of the 3 pigeons during the VI 30s to VI 360s phase, and resurged for all pigeons when extinction was implemented for both responses in the last phase.

An extension of Lieving and Lattal (2003, Exp 4) was Volkert et al. (2009, Exp 2). In it Volker et al. (2009, Exp 2) set up a procedure to determine the effect of thin schedules of reinforcement for alternative responses on resurgence. The procedure was an ABCABC reversal design including: (A) baseline, (B) FCT and FCT maintenance, and (C) intermittent reinforcement. Participants were children with problem behavior (and w/ Autism or DD). Conditions were similar to experiment 1 in that problem behavior was reinforced during baseline, and appropriate behavior was taught and reinforced during FCT and FCT maintenance. The difference was when the researchers changed the "extinction" phase to an "intermittent reinforcement" phase. During the intermittent reinforcement phase, rather than VI schedules as in Lieving and Lattal (2003, Exp 4), Volkert et al. (2009) used FR schedules. Appropriate behavior was reinforced during this phase on a thin schedule of reinforcement (FR 12), rather than placed on extinction as in experiment 1. Results show that during intermittent reinforcement condition, resurgence was observed for all participants.

The Effects of Enrichment on Resurgence

Schepers and Bouton (2015, Exp 2) used enrichment procedures in selected rats (group "reverse thinning") to identify the effect on resurgence. Responses were right or left lever pressing. In phase 1, B1 was reinforced on a VI 30s schedule for all rats. In phase 2, B1 was placed on extinction and rats were randomly divided into three groups; VI 10s, reverse thinning (an increasingly rich schedule going from VI 1200s to VI 10s), and thinning (an increasingly lean schedule going from VI 10s to

VI 1200s). Finally in phase 3, all behavior was placed on extinction. The researchers report that only group VI 10s and group reverse thinning showed “significant” resurgence. Group thinning demonstrated a decrease in B2 responses during phase 2 and a slight increase in B1 responses. Furthermore, between the final session of phase 2, to the test for resurgence session of phase 3, B1 and B2 responding decreased suggesting possible signs of early resurgence from group thinning.

The Effects of Alternating Reinforcement on Resurgence

Schepers and Bouton (2015, Exp 3) alternated the reinforcement schedule of one group of rats (Group alternating) during phase 2 of experiment 3 in order to analyze its effect on resurgence. In phase 1, all rats were reinforced on a VI 30s for B1. In phase 2, B1 was placed on extinction and, rats were reinforced differently for B2 based on their group; VI 10s, alternating (reinforcement available every other session; 1, 3, 5, and 7, on a VI 10s schedule, with alternate sessions; 2, 4, and 6, placed on extinction), and average (VI 17.5s, being the average rate of reinforcement for group alternating over the course of seven, Phase 2, sessions). In phase 3, all responses were placed on extinction. Results show that group alternating did not show as high levels of resurgence as group VI 10s and group average in phase 3. Thus alternating reinforcement schedules were successful in weakening resurgence in phase 3.

The Effects of DRO on Resurgence

Differential reinforcement of other behavior (DRO) has shown to produce resurgence, but has had mixed results (Lattal & Pipkin, 2009). Doughty et al. (2007)

studied resurgence in pigeons. They conducted five experiments in which they reinforced key pecking and found higher levels of resurgence, initiated faster at commencement of extinction, when a DRO schedule was used as opposed to a VI schedule during Phase 2. However previous findings by Mulick, Leitenberg, and Rawson (1976) and Pacitti and Smith (1977) found no differences in resurgence.

The Effects of Yoking on Resurgence

Winterbauer and Bouton (2010, Exp. 4) used yoking procedures to test for resurgence. Thirty two rats were used in experiment 4, and targeted responses were lever presses; right or left. In phase 1, B1 was reinforced on a RI 30. In phase 2, B1 was on extinction and rats were assigned to one of four groups; Group EXT (all behavior placed on extinction), Group FR 10 (B2 reinforced on FR 10 schedule), Group Yoked-VT (earned free pellets based on what their counterpart from FR 10 earned), and Group Yoked-VI (able to earn pellets contingent on their responding to B2 when their counterpart from group FR 10 responded; on a VI schedule). During phase 3, all behavior was placed on extinction. Results show that Group EXT continued to have decreased rates of B1 and B2 responding during phase 2 and 3. All other groups showed resurgence during phase 3.

The Effects of Free Feeding on Resurgence

Shahan et al. (2015) assessed to determine whether food deprivation is a necessary component to produce resurgence. The researchers state that food deprivation can cause drug relapse. They therefore suggest that food deprivation may be the cause of resurgence of an alternative behavior. The purpose of their study was

to determine whether resurgence could be produced in free-feeding rats. They created two experiments using free-feeding rats, and used sucrose and cocaine as reinforcement. In experiment 1, they reinforced B1 (lever pressing) with sucrose. In phase 2, B1 was placed on extinction and B2 (nose pokes) were reinforced on a VI 10s schedule of reinforcement with sucrose. In phase 3, both behaviors were placed on extinction. In experiment 2, they reinforced B1 (lever pressing) with cocaine, then placed B1 on extinction while reinforcing B2 (nose pokes) with sucrose (session 1, FR 1; session 2, FR 2; session 3, FR 3), then placed both on extinction. In both experiments the researchers demonstrated a resurgence of behavior in the final phase. Consequently, food deprivation is not essential to producing resurgence.

Present Study

The present study will be interested in determining the effect that quantities of reinforcement has on resurgence in pigeons. Reinforcement will be available for smaller amounts (time to consume food) for half of the pigeons at commencement of the experiment, and larger amounts of reinforcement for the other. The study will be an adaptation of Lieving and Lattal (2003), whereby key pecking (B1 and B2) will be reinforced and extinguished in the three phase procedure to produce resurgence. Afterwards, as in Lieving and Lattal (2003), the pigeons will undergo a (quasi)replication period in which the experiment will be repeated. However in the present study, the pigeons who initially received a smaller quantity of reinforcement will switch quantities with the pigeons who initially received larger quantities, and vice verse. Then all pigeons will undergo extinction again in the final (sixth) phase.

METHODS

Subjects

Four experimentally naïve King Hubbard pigeons were used in the experiment. Pigeons were housed in a state university pigeon laboratory on a 16/8 hour light/dark cycle. Each pigeon was housed in a homecage equipped with water dispenser and food cup. Water was provided freely in the pigeon's cage. Prior to the experiment, the pigeons were food restricted until they were at 90% of their free feeding weight, and maintained at this weight throughout the experiment. Food that was not earned in the operant chamber was supplemented after each session to maintain 90% of the established free feeding weight. Treatment of the pigeons was in accordance with and approved by the Institutional Animal Care and Use Committee (IACUC).

Apparatus

Four standard operant chambers were used in the experiment. Chambers measured 96.5 X 45.7 X 42.7cm (l X w X h), with 35.6 X 36.0 X 35.0cm (l X w X h) working space inside for each pigeon. Each chamber was equipped with the three response keys aligned horizontally, with 5.0cm of space between each key. Keys were 2.5cm in diameter. Each key was 6.8cm from the ceiling of the chamber and 23.5cm from the chamber floor. The keys were 9.7cm above a 6.0 X 5.1cm (l X w) food opening in which the pigeon could eat reinforcement when the food hopper was raised. A house light illuminated the inside of the chamber during sessions. Chambers

also contained a fan for ventilation, and to mask extraneous noise. Only the far right and far left keys were used for the purpose of this experiment, and both keys were illuminated white during all experimental phases; the middle key was neither illuminated nor had any programmed consequence (see Figure 1).

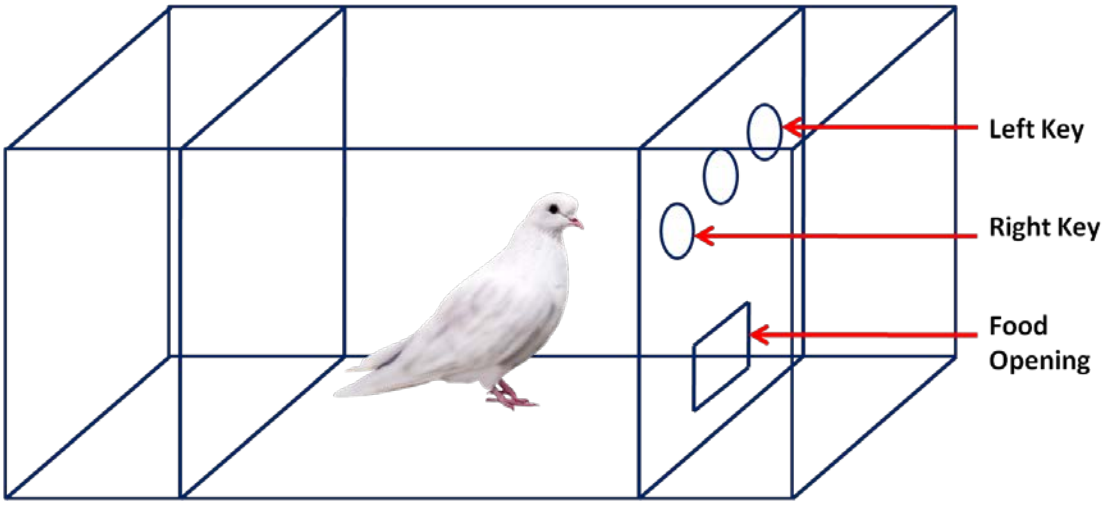

Figure 1. Illustration of operant chamber set up with pigeon facing response keys and food opening.

Procedure

Preliminary training. Initially, pigeons were trained to eat from the food hopper. The pigeons were then trained to peck either the left or right key via shaping. Then left and right key pecks were reinforced on FR schedules, whereby the initial appropriate key peck received reinforcement on a FR 1 schedule, and each subsequent trial was increased by 2, up to FR 31. On the fifth session of the FR training program, subsequent trials following each FR 1 schedule were increased by 1, up to FR 31.

There were a total of five FR schedule conditions; (1) left, (2) right, (3) alternating, (4) double, and (5) random. In the left condition, only left key pecks

produced reinforcement. In the right condition, only right key pecks produced reinforcement. In the alternating condition, reinforcement to the left key and right key alternated between days; such that left key pecks were reinforced on odd numbered days and right key pecks were reinforced on even numbered days. In the double condition, left key pecks were reinforced for two sessions, followed by two sessions of right key reinforcement, and so on. In the random condition, a reinforcement producing key was selected each session at random via coin toss. Number of sessions for the FR schedule conditions were 11, 14, 9, 24, and 8, respectively. A diagram with the schedule of conditions can be observed in Table 1.

Table 1

Number of sessions in which the terminal FR 31 schedule was met by each pigeon per condition during FR training, and SRS earned

Pigeon	Condition	# of Terminal FRs/Total	# of SRS Earned/Total
46	Left	10/11	600/660
	Right	14/14	810/840
	Alternating	9/9	513/540
	Double	24/24	1,297/1,440
	Random	7/8	398/480
4030	Left	5/11	289/660
	Right	14/14	840/840
	Alternating	9/9	540/540
	Double	24/24	1,315/1,440
	Random	8/8	447/480
68	Left	5/11	234/660
	Right	13/14	673/840
	Alternating	9/9	464/540
	Double	24/24	1,053/1,440
	Random	8/8	381/480
4036	Left	8/11	422/660
	Right	12/14	724/840
	Alternating	9/9	540/540
	Double	24/24	1,436/1,440
	Random	8/8	480/480

Pigeons received access to reinforcement from the hopper for 3-sec for each successful trial during the FR training program. For the final 3 sessions, access to reinforcement was reduced to 2-sec. Sessions ended when either 60 reinforcers were obtained or after 20 minutes of no responding.

Experimental conditions and design. The pigeons were randomly assigned to initially receive either 3-sec or 6-sec access to reinforcement for B1 (either left or

right key pecks). Reinforcement was provided on a VI 30s schedule. Pecks to the opposite key (B2) produced a 3-sec changeover delay (COD). During the COD, B1 responses did not produce reinforcement and B2 responses reset the timer. In the event that a pigeon did not engage in responding, a timeout occurred whereby both key lights turned off for 10-sec followed by a new interval schedule. A 10-sec intertrial interval (ITI) occurred after each reinforcement delivery. Sessions ended when the pigeon either earned 40 reinforcers or 60 minutes had elapsed. Phase 1 was in effect for 15 days.

In phase 2, B1 was placed on extinction and pigeons were reinforced for B2 on a VI 30s schedule resulting in 3-sec access to reinforcement for all pigeons. All other conditions were identical to phase 1. Phase 2 was in effect for 13 days.

In phase 3, all behavior was placed on extinction for 60 minute sessions. All key pecks were recorded but not reinforced. This phase lasted for 10 days.

Immediately following the test for resurgence, the first 3 phases were repeated with a few differences. In phase 4, the pigeons who initially received 3-sec access for B1 in phase 1 now received 6-sec access to reinforcement. Pigeons who initially received 6-sec access to reinforcement in phase 1 for B1 were now allowed 3-sec access to reinforcement. Phase 5 was identical to phase 2. In phase 6, all behavior was again placed on extinction as in Phase 3. All other sequences remained the same. Each of the three final phases were in effect for 10 days. Resurgence was defined as the total number of B1 responses per extinction phase sessions. Table 2 demonstrates a visual representation of the sequence of conditions for each pigeon.

Table 2

Sequence of conditions for each pigeon for each experimental phase

		PHASE					
		1 **B1: SR+** **B2: ext**	**2** **B2: SR+** **B1: ext**	**3** **Extinction**	**4** **B1: SR+** **B2: ext**	**5** **B2: SR+** **B1: ext**	**6** **Extinction**
PIGEON #	**#46**	Pecks right 3-sec	Pecks left 3-sec	EXT	Pecks right 6-sec	Pecks left 3-sec	EXT
	#4030	Pecks left 3-sec	Pecks right 3-sec	EXT	Pecks left 6-sec	Pecks right 3-sec	EXT
	#68	Pecks right 6-sec	Pecks left 3-sec	EXT	Pecks right 3-sec	Pecks left 3-sec	EXT
	#4036	Pecks left 6-sec	Pecks right 3-sec	EXT	Pecks left 3-sec	Pecks right 3-sec	EXT

Preliminary training continued for 66 sessions. The experimental phases were in effect for 68 days.

Dependent measures. Number of nontarget responses during pretraining, total number of days to complete pretraining, amount of reinforcement earned, rate of responses, and total responses for each session/phase/key of the experiment served as dependent measures.

Results

Figures 2, 3, 4, and 5 show the total number of B1 and B2 responses per session during each experimental phase for Pigeons 46, 4030, 68, and 4036 respectively.

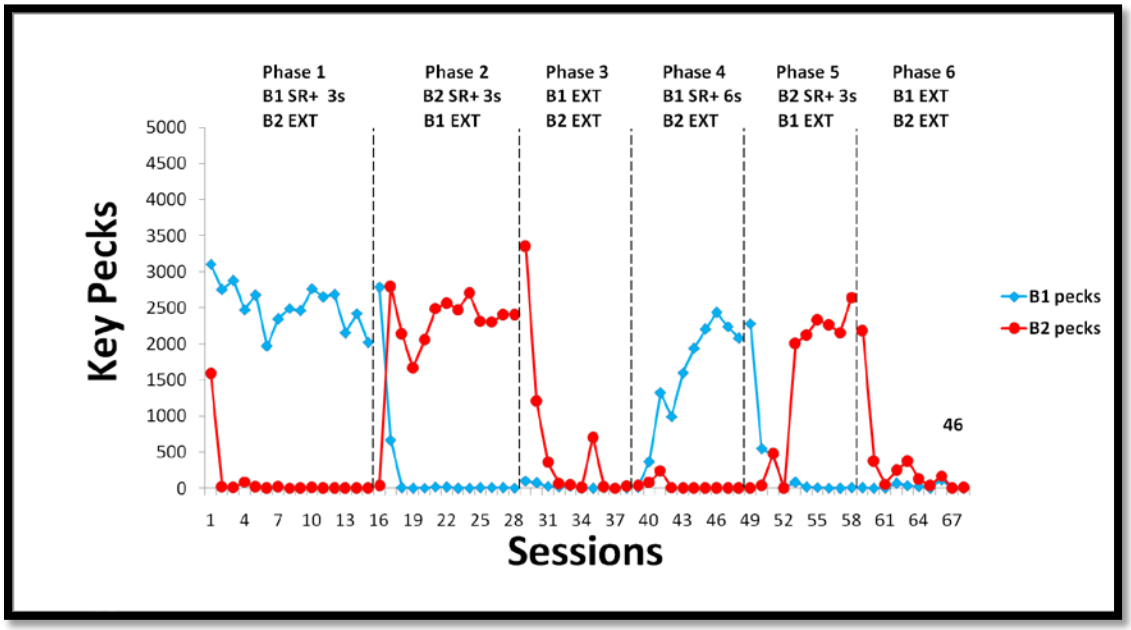

Figure 2. Total number of B1 and B2 responses per session in each experimental phase performed by Pigeon 46.

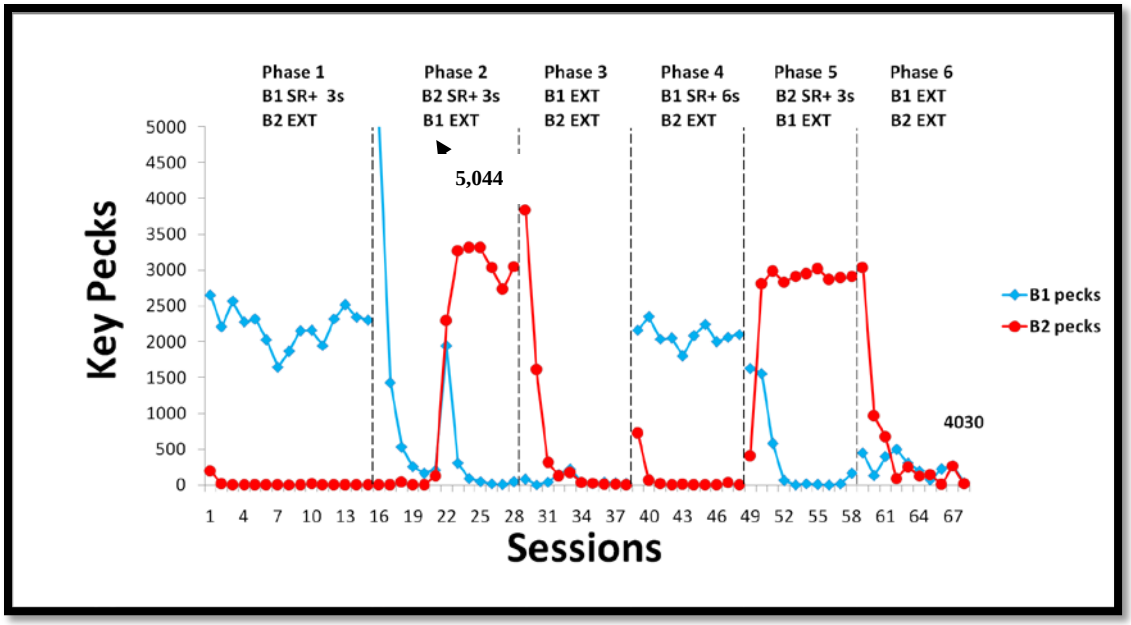

Figure 3. Total number of B1 and B2 responses per session in each experimental phase performed by Pigeon 4030.

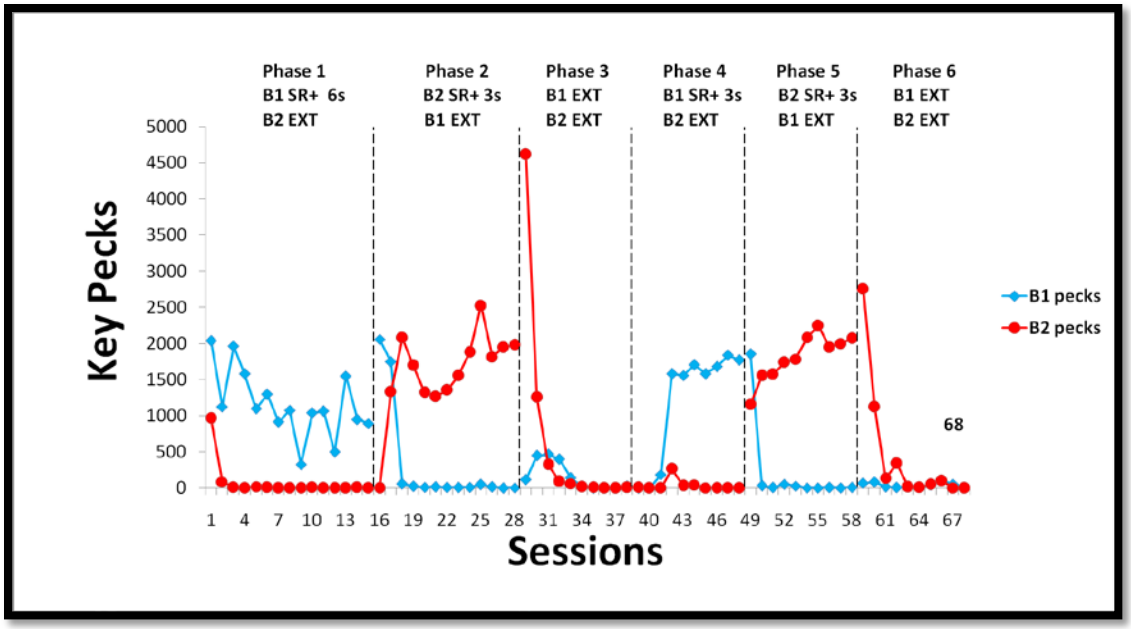

Figure 4. Total number of B1 and B2 responses per session in each experimental phase performed by Pigeon 68.

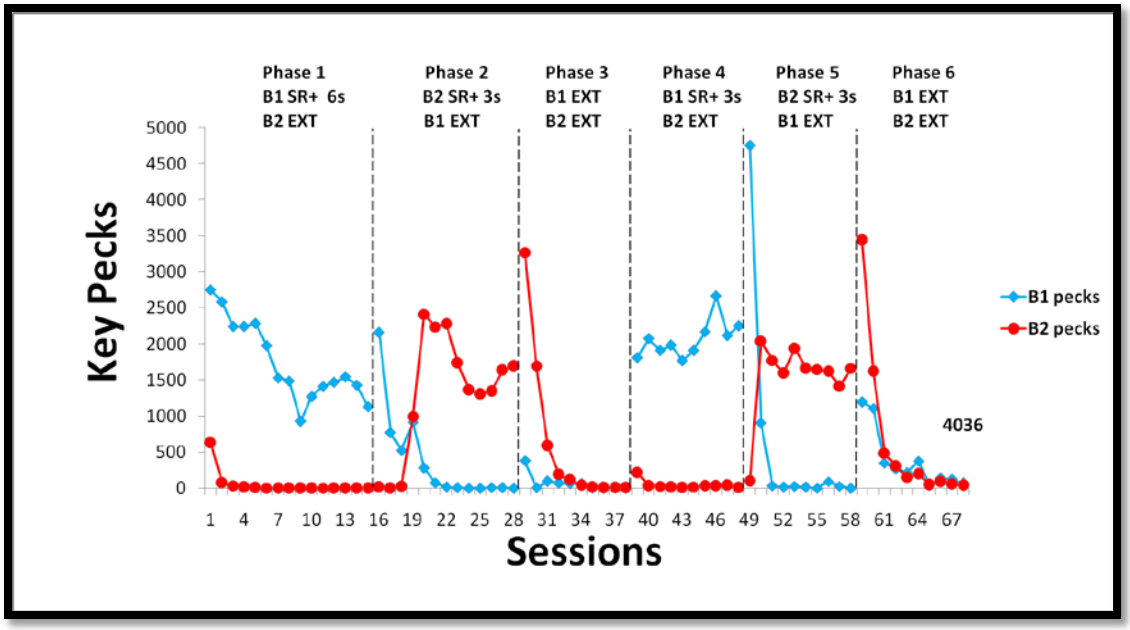

Figure 5. Total number of B1 and B2 responses per session in each experimental phase performed by Pigeon 4036.

These figures demonstrate the total number of key pecks for each session of B1 reinforcement, B2 reinforcement, and extinction. Pigeons 46 and 4030 initially received access to reinforcement for appropriate B1 responses for 3-sec, whereas Pigeons 68 and 4036 initially received access to reinforcement for 6-sec. Following the first phase of extinction, the pigeons alternated reinforcement parameters. The pigeons emitted a relatively high number of responses, with 1,500 to 3,000 key pecks per reinforcement session. The total number of key pecks during the experimental phases in which all reinforcers were attained ranged from 928 to 3,567 per session. High levels of responding occurred during the first few sessions of each extinction phase, and at the beginning of most reinforcement phases.

Two pigeons had more resurgence after 6-sec of reinforcement on B1 (Pigeons 4030 and 68), while the other two pigeons (46 and 4036) had more resurgence after 3-sec of reinforcement on B1 (see Figure 6).

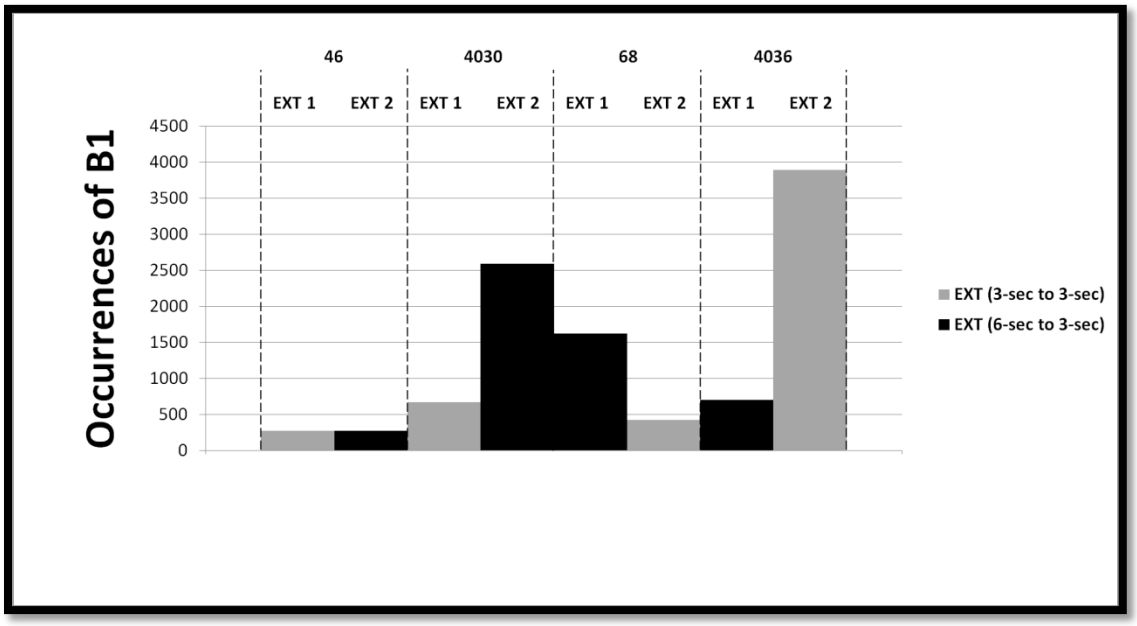

Figure 6. Total number of B1 responses for each extinction phase performed by all pigeons.

However, Pigeon 46 only demonstrated a total of 4 more resurgence key pecks after 3-sec of reinforcement on B1compared to 6-sec. Pigeon 4036 had the biggest difference in resurgence; 3,191 more resurgence key pecks after 3-sec of reinforcement on B1 than 6-sec.

Amounts of B1 responding per extinction session varied (see Figure 7).

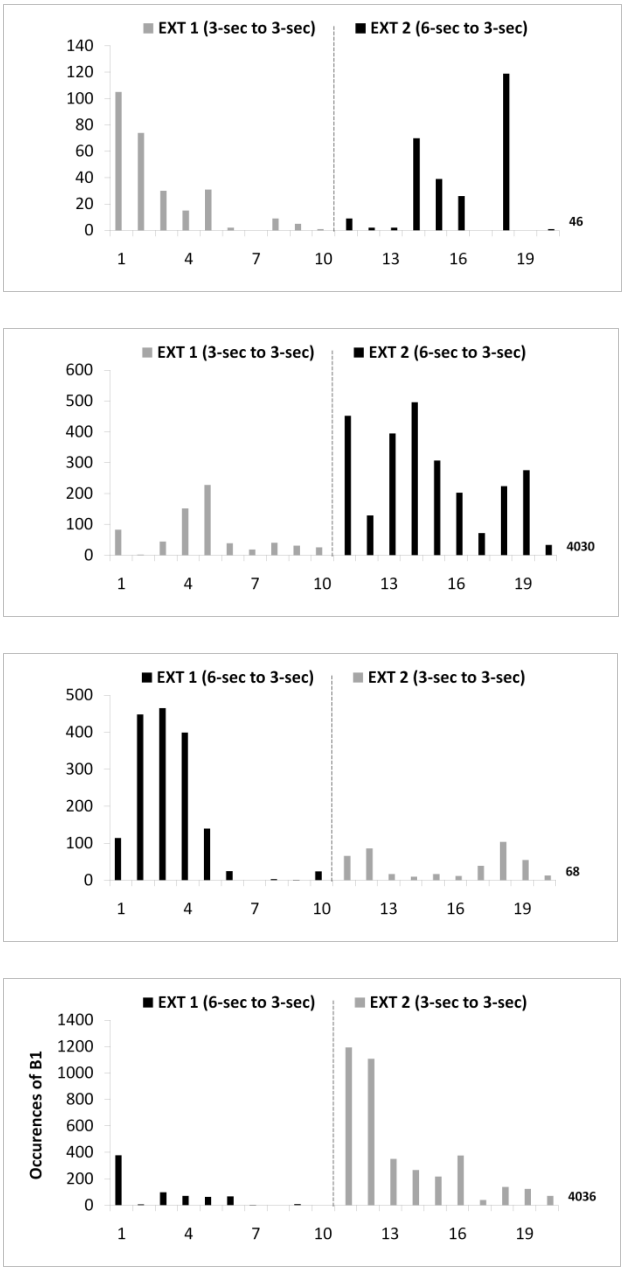

Figure 7. Number of B1 responses per session for each extinction phase performed by all pigeons.

Pigeon 46 demonstrated a gradual decline of resurgence following an initial reinforcement of B1 for 3-sec, and fluctuations in resurgence responses following reinforcement of B1 for 6-sec. On the contrary, Pigeon 4030 and 68 had a gradual decline of resurgence responses following reinforcement of B1 for 6-sec, and fluctuating rates of responding following reinforcement of B1 for 3-sec. Pigeon 4036 demonstrated a gradual decline in responding across extinction sessions for both extinction phases.

Persistence of B1 responding during the extinction phases varied among the pigeons. Figure 8 shows the number of extinction sessions completed before occurrences of B1 reached zero for all pigeons.

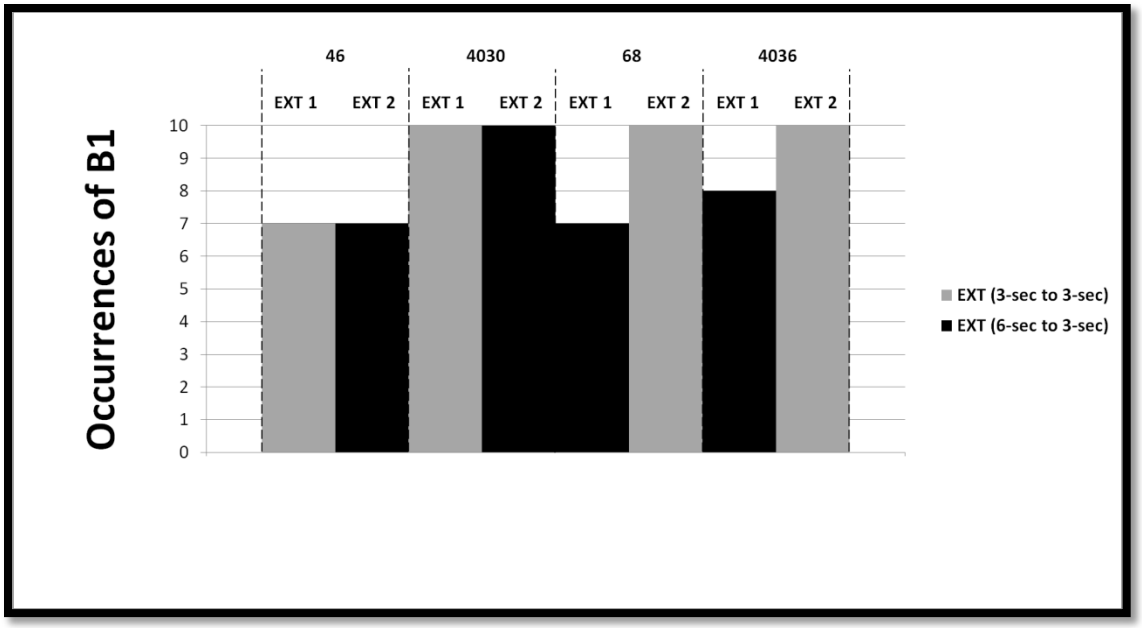

Figure 8. Number of extinction sessions completed before occurrences of B1 reached zero for all pigeons.

Note. A data height of ten would indicate that the pigeon never reached zero occurrences of B1 in the respective extinction phase.

A maximum of 10 sessions was allocated per extinction phase. Pigeons 4030, 68, and 4036 never reached zero occurrences of B1 during the extinction phase following B1 reinforcement of 3-sec. Pigeon 46's B1 responding reached zero by the seventh session of each extinction phase. By the eighth session of the extinction phase following reinforcement of B1 for 6-sec, B1 responding had ceased for all pigeons except Pigeon 4030; who never reached zero occurrences of B1 responding in either extinction phase.

The total number of responses per phase decreased over the course of the experiment possibly due to a higher number of sessions in phase 1 and 2 (see Table 3).

Table 3

Total number of B1 and B2 responses per session, and number of sessions per phase

Pigeon	Phase	B1 Responses	B2 Responses	# of Sessions
46	1	37,856	1,758	15
	2	3,554	28,337	13
	3	272	5,767	10
	4	15,195	375	10
	5	3,433	14,020	10
	6	268	3,587	10
4030	1	33,307	238	15
	2	10,100	21,165	13
	3	666	6,137	10
	4	20,906	833	10
	5	4,036	26,576	10
	6	2,588	5,564	10
68	1	17,410	1,109	15
	2	4,018	20,735	13
	3	1,619	6,381	10
	4	11,894	362	10
	5	2,011	18,133	10
	6	419	4,522	10
4036	1	26,297	771	15
	2	4,760	17,025	13
	3	698	5,931	10
	4	20,651	427	10
	5	5,871	15,448	10
	6	3,889	6,422	10

In order to assess whether this had an effect on resurgence, key pecks were also evaluated based on the mean number of stable B1 responses when B2 was reinforced. Figure 9 demonstrates the multiplicative increase of B1 per extinction session in relation to the mean number of B1 responses during the last six sessions of the B2 reinforcement phase for all pigeons.

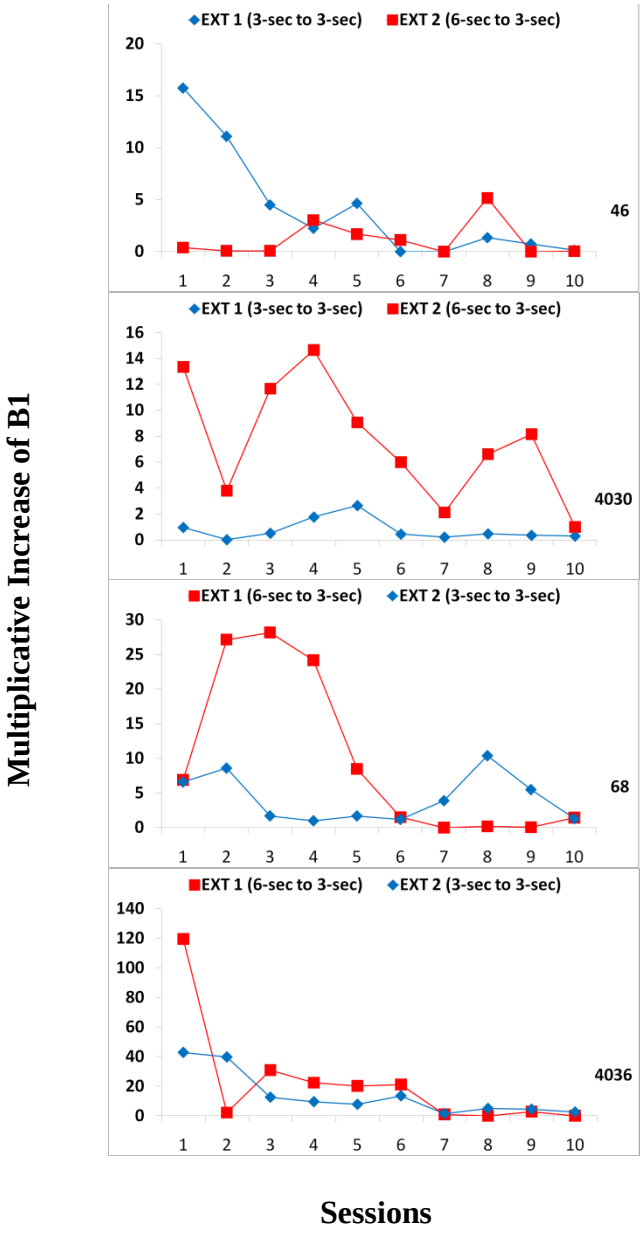

Figure 9. Multiplicative increase of B1 per extinction session by factors of itself in relation to the mean number of responses of B1 during the last six sessions in which B2 was reinforced for all pigeons.

Note. Y-axis numbers are not equal across birds.

Data show that Pigeons 4030, 68, and 4036 had higher levels of resurgence when B1 was initially reinforced for 6-sec rather than 3-sec. For example, Pigeon 4030 had 13.36 times more B1 responding in the first extinction session when B1 was initially reinforced for 6-sec (in relation to occurrences of the mean number of B1 responses in the final six sessions of the previous phase), compared to only .97 times more B1 responding in the first extinction session when B1 was initially reinforced for 3-sec. In contrast, Pigeon 46 had higher levels of resurgence when B1 was initially reinforced for 3-sec, under this criteria.

DISCUSSION

The present findings revealed no difference in levels of resurgence when quantities of reinforcement (3-sec vs 6-sec) were the main independent variable. Previous findings demonstrate that resurgence is repeatable and does not diminish its effect over time (Lieving and Lattal, Exp 2), however, it was found that resurgence was not dependent on the magnitude of reinforcement which the current study employed.

In the current study, two of the four pigeons were initially reinforced for 3-sec for B1 (left or right key pecks) and the other two were initially reinforced for 6-sec. Then all pigeons received 3-sec for B2 (pecks to opposite key) in phase 2, and placed on extinction for all behavior in phase 3 (test for resurgence). Previous research would suggest that the two pigeons who initially received reinforcement for 6-sec would engage in higher levels of resurgence relative to the other two pigeons because of the added reinforcement (Mace et al., 2010; Podlesnik and Shahan, in press). However, it was found that the pigeons who initially received reinforcement of B1 for 3-sec engaged in 92% (Pigeon 46) and 93% (Pigeon 4030) more B1 responses during the test for resurgence than when B2 was reinforced. In contrast pigeons who initially received reinforcement for 6-sec engaged in only 59% (Pigeon 68) and 85% (Pigeon 4036) more B1 responses during the test for resurgence than when B2 was reinforced. This ABC design was extended to an ABCDBC design which allowed for an analysis

of each individual pigeon's responses during both extinction phases relative to when it was initially reinforced for 6-sec rather than 3-sec. It was determined that the number of B1 responses for each extinction phase performed by all pigeons were inconsequential, and quantities of reinforcement proved unpredictive towards levels of resurgence.

The difference in the amount responding during extinction phases across subjects suggest that numerous other variables are also responsible for levels of resurgence; one possible variable in the current study being satiation. In phase 1, Pigeon 68 failed to complete ten of the fifteen sessions and ceased pecking after approximately 30 minutes of responding each session. However, its weight remained stable throughout the experiment. The pigeon received 6-sec of reinforcement per appropriate response in phase 1, and it was not until moving to phase 2 (3-sec of reinforcement) that it completed most (11/13) sessions. This pattern of responding could suggest that satiation was occurring mid-session in phase 1.

Another possible confound was the presence of a third, middle key. Only the far right and far left keys were illuminated during the entirety of the experiment. Though responses to the middle key weren't as high as responses to the illuminated keys, responding still occurred. This may have had an impact on the results of the experiment. Pigeons 4030 and 4036 engaged in responding to the middle key. Pigeon 4030 pecked a total of 62 times to the middle key. Pigeon 4036 pecked the middle key 195 times; 125 of those pecks occurred in the first extinction phase.

An additional characteristic of the experiment that should be considered was the length of time for each session. The current study utilized 60 minute sessions throughout the experiment. Previous research (Kincaid et al., 2015; Lieving and Lattal, 2003; Schepers & Bouton, 2015; Winterbauer & Bouton, 2010; Winterbauer & Bouton, 2012) employed 30 minute sessions which appeared to be sufficient time for all pigeons to complete the session, and for collecting data during extinction phases. Most pigeons in the current study were able to complete the reinforcement phases within 28 to 32 minutes. In order to prevent disturbing the other pigeons during the current study, pigeons were left in the chambers until the final pigeon completed the session. During extinction phases, the pigeons stayed in the operant chamber for the entire 60 minutes. These total amounts of time may have been too extensive which could have influenced the results.

Reinforcement history and pigeon characteristics may have been a confound in the present study. In the initial sessions of each reinforcement phase, Pigeon 46 only pecked when the operant chamber door was open. It was shaped to peck with the door closed, by pairing each food delivery with the incremental lowering of the chamber door, until the door was ajar and ultimately closed. The results from these initial sessions may have had an influence on the overall data. Furthermore, Pigeon 4030 appeared to have a foot condition on one of its feet in which its toes curled inwards. The experimenter placed brown Kraft paper down inside the chamber to prevent the pigeon’s foot from becoming caught between the wire mesh flooring. Eventually, the pigeon appeared to reach the key successfully. However it is unclear

whether the pigeon may have made errors during initial sessions due to a lack of stability inside the chamber.

Quantities of reinforcement were only a determining factor in rates of resurgence when we compared responding during extinction to stable mean rates of responding during B2 reinforcement. It can be determined that incorporating total key pecks was not effective in gauging levels of resurgence due to a high level of B1 responding at the start of the B2 reinforcement phases. Lieving and Lattal (2003) implemented extinction procedures to totally eliminate B1 and B2 responding at the end of their prospective reinforcement phases; prior to reinforcing the new behavior. Lieving and Lattal (2003) also shaped and reinforced each behavior prior to implementing the VI schedule procedure, which allowed for more stable data throughout each reinforcement phase. At some point during the current study, all pigeons were exposed to many sessions in which little to no reinforcement was earned. In these early phase sessions, prior to acquisition, there were a high rate of inappropriate responses (pecks to the nonreinforcement key) and low rates of appropriate responses. Therefore, rather than emitting appropriate responses, the pigeons were exhibiting extinction burst during the transition from B1 to B2 reinforcement which was a variable that may have caused inconsistency in the data.

Continued research is essential in understanding the elements which produce resurgence, and to what degree quantities of reinforcement can have an effect. Studying resurgence could inform researchers to the cause in relapse of drug abuse

(Higgins, Silverman, & Heil, 2008), and alcohol abuse (Dougherty et al., 2014). Resurgence has been prevalent when treating children with disabilities and problem behavior (Volkert et al., 2009; Hoffman & Falcomata, 2014; Marsteler & St. Peter, 2014). The present study utilized pigeons to determine the difference in effect that high and low quantities of reinforcement would have on resurgence. The present study showed no difference in rates of resurgence between the two, except when we factor mean rates of stable responses.

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