Effects of Rich and Lean Treatment Contexts on Renewal

by

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Abstract

Title: Effects of Rich and Lean Treatment Contexts on Renewal

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Relapse of problem behavior following behavioral intervention can occur for many reasons, including a change in setting after treatment. Reappearance of a previously extinguished behavior due to a context change is termed renewal. Laboratory models have demonstrated renewal by training a target behavior in one stimulus context, extinguishing the behavior in another context, and testing for relapse in the training context, where the behavior remains in extinction. Basic-research studies of relapse have also shown that conditions of the treatment environment, such as reinforcement schedules, can affect the amount of relapse observed. Assuming that quality of the treatment context could have an impact on relapse, this translational study investigated whether an enriched treatment environment increases renewal. Child participants were exposed to an ABA sequence of contexts, signaled by color-coded (e.g., red-blue-red) stimuli. Reinforcement was provided for target responding in Context A, and the target response was under extinction conditions in Context B, and in a return to Context A. In Context B across conditions, high-preferred or low-preferred toys were present, representing a more enriched treatment context or a leaner treatment context, respectively. For one participant, greater relapse occurred following exposure to the enriched treatment context. For the other two participants, target responding was not eliminated when extinction contingencies were introduced. Possible explanations and implications will be discussed. Examining the effects of treatment conditions can provide a platform for
understanding ways to decrease relapse following extinction-based treatments of problem behavior.

*Keywords:* renewal, resurgence, reinforcement, relapse, translational research, children
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Dedication

This thesis is dedicated to my parents, Raj and Srilatha, to my brother and best friend, Aditya, and to my favorite pup, Kashew.
Introduction

In clinical settings, treatment of problem behavior in individuals with developmental disabilities often involves manipulating consequences of behavior (e.g., Hanley, Iwata, & McCord, 2003). Problem behavior can include any maladaptive behavior impeding learning or daily functioning, leading to social stigma, or endangering the individual or others (e.g., disruptive behavior, self-injurious behavior, stereotypy). Behavioral interventions targeting reduction of problem behavior may include modification of motivating operations, use of extinction or differential reinforcement, or some combination of these procedures. Two such procedures, noncontingent reinforcement and differential reinforcement of alternative behavior, have been demonstrated to be effective in decreasing problem behavior.

Noncontingent reinforcement (NCR) involves identifying the reinforcer maintaining problem behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994), and delivering functionally equivalent reinforcers independently from the behavior targeted for reduction (Carr, Severtson, & Lepper, 2009). NCR is often conducted as a time-based procedure, in which preferred stimuli are delivered at predetermined intervals. This procedure is intended to reduce the individual’s motivation to engage in problem behavior (Carr & LeBlanc, 2006). NCR is an effective treatment for several topographies of problem behavior, including those maintained by automatic reinforcement. However, issues with NCR may arise in implementation or discontinuation. Without careful monitoring of implementation, problem behavior may be unintentionally reinforced. Further, as discussed by Iwata, Smith, and Michael (2000), problem behavior is likely to return when NCR is discontinued. Finally, NCR often requires a great amount of therapeutic
resources. Therefore, it is possible that problem behavior decreased through NCR in a clinical setting will reappear in environments without such supports.

Other treatments for problem behavior may be difficult to maintain across environments, as well. Differential reinforcement of alternative behavior (DRA) is another common method of treating problem behavior. DRA is a well-established method for treating problem behavior (Petscher, Rey, & Bailey, 2009), which involves extinguishing problem behavior and providing a functionally equivalent reinforcer for an appropriate alternative response. Benefits of DRA include the introduction of new and appropriate skills. Additionally, this treatment leads to reductions in severe problem behavior, and is unlikely to produce undesired side effects. During treatment, however, a functional reinforcer (i.e., the maintaining reinforcer of the problem behavior) may not be available at times, leading to return of the problem behavior. This issue, preventing maintenance of DRA, involves unintentional extinction of the alternative response. Additionally, the treatment may be too time consuming or resource intensive to continue long term in less structured environments.

Practitioners struggle with maintaining behavior change across time (Stokes & Osnes, 1989). Although reliable methods for reducing problem behavior exist, including NCR and DRA, relatively long-term results are difficult to ensure (Nevin & Wacker, 2013). Another consideration is that DRA may need to be implemented for a lengthy period of time before the alternative behavior maintains in the absence of treatment (e.g., Wacker et al., 2011). One component of differential reinforcement is extinction. Extinction is effective in reducing behavior through discontinuation of the response-reinforcer relation, but effects may be impermanent (Bouton, Winterbauer, & Todd, 2012). Therefore, DRA treatments might be impermanent due to the same behavioral processes making extinction’s effects impermanent.
The failure of behavior change to maintain can lead to relapse of eliminated or reduced behaviors. Findings from basic laboratory research allow isolation of factors contributing to relapse and, therefore, could provide insight into ways to improve behavioral treatments. Specifically, the reappearance of previously extinguished behavior due to context change describes a type of treatment relapse known as renewal. Studies of renewal typically involve training in Phase 1, followed by two extinction phases, changing only the context across phases. Different contexts are distinguished by varying stimulus conditions (e.g., different rooms, colors, scents, etc.).

Bouton, Todd, Vurbic, and Winterbauer (2011) demonstrated renewal of operant behavior in rats, testing three models of renewal. In a series of experiments, stimulus contexts “A,” “B,” and “C” were manipulated during phases consisting of training, extinction, and tests for renewal also in extinction. To test for ABA renewal, a behavior was trained in Context A in Phase 1, using a variable-interval (VI) 30-s schedule of reinforcement. The behavior was subsequently extinguished in Context B in Phase 2. Extinction conditions continued as a test when rats returned to the original Context A in Phase 3, and the behavior trained in Context A in Phase 1 returned. This basic-research design provides one way to analyze relapse following clinical treatment. ABA renewal could represent learning of problem behavior in a home setting, elimination of problem behavior in a clinic setting, followed by reappearance of problem behavior in the home despite treatment remaining in place.

Bouton et al. (2011) demonstrated AAB renewal as well, training a target response in Context A in Phase 1, using a VI 30-s schedule of reinforcement, extinguishing responding while participants remained in Context A, and testing for renewal in Context B when extinction contingencies continued. The occurrence of AAB renewal suggests that any change from the extinction context can cause
renewal. Similarly, in an ABC model, experimenters arranged for training to be conducted in Context A in Phase 1 using a VI 30-s schedule of reinforcement. Next, target responding was extinguished in Context B, and extinction continued in Context C. Renewal occurred in this ABC model, demonstrating again that any switch from the context of extinction, not necessarily back to that of training, can lead to a reappearance of extinguished responding. Comparing these two models of renewal with clinical treatment, AAB and ABC renewal could represent relapse when entering a novel environment (e.g., a grocery store) following treatment in a clinical setting.

Findings of renewal such as those described by Bouton et al. (2011) suggest that effects of extinction may not persist in the presence of a context change, and are useful in conceptualizing relapse following behavioral intervention. In clinical situations, a commonly occurring example of the impermanence of extinction-based treatments is when treatment effects do not maintain due to a transition away from the treatment context. Specifically, relapse of problem behavior can occur when a child returns to the context in which problem behavior was originally learned (e.g., home, school), or enters a novel context (e.g., park, grocery store, doctor’s office). These are clinical examples of renewal in which problem behavior reappears despite extinction-based treatment procedures remaining in place (see Podlesnik, Kelley, Jimenez-Gomez, & Bouton, 2017, for a review). Reducing problem behavior across environments and maintaining these effects over time is a crucial goal for behavioral practitioners (Durand & Carr, 1991). As emphasized by Baer, Wolf, and Risley (1968) and Stokes and Baer (1977), in order for behavioral change to be considered effective, it must generalize. This includes generalizing both problem behavior reduction and skill acquisition across settings.

Often, upon an individual’s return to the setting in which problem behavior was learned, caregivers are responsible for behavior management. Caregivers are
commonly trained to enforce the contingencies introduced during treatment (Kelley, Liddon, Ribeiro, Greif, & Podlesnik, 2015). However, Kelley et al. demonstrated significant effects of stimulus contexts despite continuation of extinction contingencies in pigeons, as well as in two children with Autism Spectrum Disorder (ASD). In both species, an ABA sequence of contexts was tested, with an ABB (i.e., reinforcement, extinction, extinction) sequence of contingencies. In Experiment 1 with pigeons, contexts A and B were distinguished by different rates of alternation of key-light color stimuli. In Phase 1 (Context A), key pecking responses were reinforced on a fixed-interval (FI) 10-s schedule. In Phase 2 (Context B), key pecking responses were extinguished. In Phase 3 (Context A), extinction remained in place for key pecking responses. In Experiment 2 with human participants, Contexts A and B were distinguished by different colored stimuli in the research area. Context A included yellow clothing and materials, and context B included green clothing and materials. In Phase 1 (Context A), predetermined mastered tasks (e.g., tracing, math problems) were reinforced on a fixed-ratio (FR) 1 schedule. In Phase 2 (Context B), task completion was extinguished. In Phase 3 (Context A), extinction remained in place for task completion. ABA renewal effects were found in Experiment 1 with pigeons and in Experiment 2 with humans. These findings lend support to interspecies generality, and demonstrate how context changes can interfere with maintenance of treatment effects. This study provided a basis for study of translational research on treatment relapse with renewal.

Consistent with basic findings of renewal, clinical treatments reveal that changes in setting can lead to reappearance of eliminated problem behavior. In a study conducted by Durand and Carr (1991), a functional-communication response was taught to replace problem behavior (i.e., DRA was used) with three participants. For all participants, problem behavior decreased following teaching of
the replacement response. Despite successful maintenance of the alternative response and low levels of problem behavior in two participants, one participant’s problem behavior returned to high levels during follow-up assessment in a new classroom the next year. Articulation of the communication response had not maintained over time and in a new setting, and additional articulation training was required to decrease problem behavior again. Thus, a potential factor contributing to relapse in this example could have been the transition to a new classroom with a new teacher, consistent with ABC renewal.

While renewal represents the occurrence of relapse due to context change, resurgence is another type of treatment relapse occurring when a target behavior is reinforced and subsequently extinguished. The target behavior reemerges when introducing extinction for a more recently reinforced alternative behavior (Bouton, Winterbauer, & Todd, 2012). Resurgence is relevant to applied settings, as it could depict the consequences of treatment failure following DRA (Volkert, Lerman, Call, & Trosclair-Lasserre, 2009). Laboratory models have proven useful in demonstrating resurgence by modeling DRA. Typically, in Phase 1 of resurgence models, a target response is reinforced. In Phase 2, as in DRA, the target response is extinguished and an alternative response is reinforced. In Phase 3, both responses are extinguished (Nevin & Wacker, 2013). This arrangement usually results in reappearance of the target response, despite a history of extinction, i.e., resurgence.

Along these lines, resurgence studies comparing different reinforcement rates in Phase 2 have yielded important results. Several studies conducted with pigeons and rats showed that when denser reinforcement rates are used to train an alternative response in Phase 2, the target response is decreased more rapidly, but such conditions lead to greater resurgence in Phase 3 (Craig & Shahan, 2016; Leitenberg, Rawson, & Mulick, 1975; Sweeney & Shahan, 2013). Craig and Shahan (2016) suggested that low rates of reinforcement in Phase 2 might not result
in resurgence. Further, in a translational study, Pritchard, Hoerger, Mace, Penney, and Harris (2014) examined the effects of different rates of reinforcement during treatment on relapse in an individual engaging in aggressive and disruptive behavior. One therapist provided the participant with a higher rate of reinforcement for appropriate requests for attention than the other therapist. Relapse of problem behavior occurred at much higher rates with the therapist providing higher rates of reinforcement than the therapist providing lower rates of reinforcement. These translational findings further support the basic findings that enriched reinforcement conditions during treatment may lead to greater relapse.

Podlesnik and Kelley (2014) conducted a relevant experiment with pigeons demonstrating resurgence, illustrating the role that quality of treatment context might play in relapse. The two most relevant conditions from their study were a modified resurgence procedure and a renewal control procedure. In both conditions, two key pecking responses were available. Table 1 shows the schedule of reinforcement for each key. In Phase 1 of both conditions, a VI 60-s schedule was used to train the target response, while the second key was inactive and unlit. In both conditions during Phase 2, a key light turned on that was associated with the alternative response. In Phase 2 of the Modified resurgence procedure, the alternative response was trained on a VI 60-s schedule while the target response was extinguished. In Phase 2 of the renewal control procedure, the alternative response was available but was not reinforced, and the target response was extinguished. In Phase 3 of the modified Resurgence procedure and the Renewal control procedure, the alternative and target responses were extinguished, and the stimulus (i.e., lit key) for the alternative response was removed. Thus, contextual conditions were identical between the renewal control and modified resurgence procedures. However, reinforcement for alternative responding was not provided in Phase 2 with the renewal control. Across pigeons in the modified resurgence
procedure, the target behavior resurfaced immediately at a high rate. Across pigeons in the renewal procedure, relapse was not observed reliably. Notably, these findings suggest that presence of reinforcement in Phase 2 leads to greater relapse upon context change in Phase 3, while the absence of reinforcement in Phase 2 can result in little to no return of the target behavior, despite a context change. Presence of a reinforcer in Phase 2 could represent a richer treatment context, leading to greater relapse.

Basic-research studies of relapse are often conducted under the assumption that results could generalize to clinical applications (Mace & Critchfield, 2010). If richer treatment contexts lead to greater relapse in Phase 3 in models of relapse, it follows that similar patterns could occur in clinical treatments of problem behavior. Greater reinforcement rate or quality (i.e., richer treatment contexts) during NCR or DRA could decrease problem behavior rapidly in the short term, but lead to greater magnitude or intensity of problem behavior reappearance (e.g., Pritchard et al., 2014).

The present study sought to assess whether enriched treatment contexts increase renewal using a translational-research model. Effects were examined with simulated problem behavior in children across three phases. In Phase 1, an arbitrary target behavior was trained in Context A. In Phase 2, the target behavior was extinguished in Context B. In Phase 3, the target behavior remained in extinction during a return to Context A to assess renewal of the target behavior. A nonreinforced control response was available throughout all three phases to assess any general increases in variability of responding. In the condition simulating a rich treatment context during Phase 2, high-preferred toys were present. In the condition simulating a lean treatment context during Phase 2, low-preferred toys were present. Differences in the rate of the target behavior between the two conditions in Phase 3 were examined. As it has been demonstrated that richer treatment contexts
are likely to promote relapse in resurgence models (e.g., Craig & Shahan, 2016; Podlesnik & Kelley, 2014), greater renewal in the rich condition might suggest that withdrawal of relatively more favorable treatment conditions would produce more rapid and/or greater relapse. Findings from this study allow us to compare the effects of qualitatively different treatment contexts on renewal.
Method

Participants and Setting

Three children, aged 5, 9, and 11, recruited through The Scott Center for Autism Treatment, participated in the study. Wade, 5, and Wanda, 9, had prior diagnoses of ASD, and Margaret, 11, had no prior diagnoses. All participants were able to sit for 2-min sessions without engaging in severe problem behavior (e.g., self-injurious behavior, disruptions). All participants followed simple instructions, imitated gross motor movements, and were able to engage in the motor response of picking up a ball and dropping it into a box. Wade and Wanda had limited vocal abilities, and communicated using Proloquo2Go, a speech-generating application on their Apple iPad devices. Margaret had an advanced verbal repertoire, and attended a local middle school.

Sessions were conducted in treatment rooms at The Scott Center for Autism Treatment. Each room contained one table, two chairs, respective contextual stimuli, task materials, and data collection materials. A recording device was kept on the opposite side of a one-way mirror. The experimenter and the participant were the only individuals present in the room. A second experimenter collected data and recorded sessions through a one-way mirror.

Materials and Dependent Measures

In this study, edible items were used as reinforcers. A multiple-stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was conducted at the outset of each session to identify preferred edibles. The same edibles were presented in every MSWO throughout all sessions for each participant.
At the outset of the study, each participant’s caregiver or therapist was asked for a list of preferred tangible items (i.e., toys, games, etc.). A free-operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998; Sautter, LeBlanc, & Gillett, 2008) was used to identify high-preferred and low-preferred items, at the start of each visit, for Wade. However, for Wanda and Margaret, a free-operant preference assessment was determined to be insufficient and inappropriate. Wanda exhibited extremely low levels of toy engagement during initial free-operant preference assessments, and an MSWO was used to determine toy preference for the duration of the study. Margaret was presented with an array of toys at the start of each visit, and was asked to rank them in order of preference.

Task materials also included Montessori Object Permanence Boxes. This study involved two such boxes, a natural wood box to represent the target response, and another painted green to represent a control response. Figure 1 shows the target response box. Data collection materials included a clipboard, paper, pen, timer, and a laptop. Context A and Context B each contained contextual stimuli of the same color (i.e., red or blue, depending on the context, counterbalanced across participants), including color-coded chairs, placemats, plates, pens, clipboards, timers, and the experimenter’s shirts. Figure 2 depicts each arrangement of contextual stimuli.

The primary observer tracked the number of target responses and duration of toy engagement during all phases. A target response consisted of one instance of the participant retrieving the ball and putting it in the hole of the object permanence box, so that the ball fell through. This number was converted into rate as responses per minute. Duration of toy engagement was recorded when the participant engaged with the toy, defined as touching or looking at (for items such as tablets, books, light toys, etc.) the item, measured in seconds, with immediate onset and a three second offset. Total duration of engagement was divided by total session duration to
provide the percentage of the session during which toy engagement occurred. Additionally, emotional behavior, responses of functional equivalence to the target response (e.g., requesting or reaching for edibles), and responses in the non-target (control) box were tracked. Reinforcer deliveries by the experimenter were tracked, as well.

**Procedure**

Participants each experienced six phases, experiencing the rich condition once and the lean condition once. Table 2 displays the arrangement of conditions and contingencies. An ABA renewal model was used, with an ABB model of contingencies for the target behavior. Each participant experienced the three phases twice, yielding two tests for renewal, in Phase 3 of each condition. During Context B, either high- or low-preferred toys were available to evaluate the effects of high-versus low-preferred toys on target responding in Phase 2 and Phase 3.

Phase 1 occurred in Context A, during which the target response was trained on a variable-ratio (VR) 2 schedule of reinforcement, using edibles. Phase 2 occurred in Context B, during which the target response was extinguished, and either high- or low-preferred toys were present. Phase 3 occurred in Context A, and the target response remained on extinction. All phase changes occurred within visits, following visual inspection of level, trend, and variability of graphs depicting data from prior sessions. Throughout all phases, no reinforcement was provided for responding that occurred on the control box. While the position of the target and control response boxes remained the same within participants, positioning was counterbalanced across participants. During all phases, both object permanence boxes were located on the table, eight to 12 inches from the participant. The color correlated with each context was counterbalanced across
participants (Context A for Participant 1 was red, Context A for Participant 2 was blue, etc.). All sessions were video recorded.

**Phase 1: Reinforcement.** In Phase 1, the participant was in Context A. The target response (i.e., inserting the ball into the hole in the top of the natural wood object permanence box) was trained. Then, the experimenter delivered the instruction, “You can put the ball in the box. You can do as much or as little as you want. Ready, set, START.” Model prompts were used and faded, by decreasing assistance with increasing independence. Each participant received edibles on an FR 1 schedule of reinforcement for the first 10 independent responses as training prior to Session 1. Thereafter, the schedule thinned to a VR 2 schedule of reinforcement for the duration of each subsequent session. A VR 2 schedule of reinforcement was used to mimic reinforcement in the natural environment, in which intermittent reinforcement is more likely to occur than continuous reinforcement. Additionally, a VR 2 schedule was used to enhance experimental control; if a participant were exposed to an FR 1 schedule of reinforcement in Phase 1 in Context A, followed by extinction in Phase 2 in Context B, the shift in reinforcement schedules would be sudden and pronounced, and responding could come under the control of the schedule of reinforcement. A delay in detection of the altered contingencies provided time for responding to come under the control of the change in stimulus contexts (i.e., color-coded environments). In Phase 1, the control response (the green object permanence box) was available, but was not reinforced. There were no toys available.

When target responding occurred at a high level, with little to no variability, Phase 2 began. Within each participant, variability was determined by past responding. If a participant had engaged in a large range of responses across sessions, and responding increased or decreased in the most recent session, a slight change in rate of responding in subsequent sessions was acceptable if it occurred
within that participant’s typical range. If the rate of responding in the most recent session was calculated to be outside the participant’s typical range of responding, the current phase continued. When switching from Phase 1 to Phase 2, if there was a downward trend in response rate (i.e., lower response rate in the most recent sessions than in former sessions), a phase change was not made (Johnston & Pennypacker, 2009). A slight upward trend was considered acceptable when moving from Phase 1 to Phase 2, as the target response rate was expected to increase when reinforcement was available.

**Phase 2: Extinction-Rich/Extinction-Lean.** In Phase 2, the participant was in Context B. Context B was signaled by different colored contextual stimuli than Context A. The experimenter delivered the same instruction as in Phase 1. The target response was placed on extinction (i.e., the box was still present but responses were not reinforced). The control response was available, but was not reinforced. Depending on the condition, either two high- or low-preferred items were available in Phase 2, placed in front of the object permanence boxes. The preference assessment conducted at the start of each visit determined the two items present during sessions in Phase 2.

Phase 3 began when target responding occurred at a low level, with little to no variability. Visual inspection of variability was conducted similarly to that in the initial phase change. When switching from Phase 2 to Phase 3, if there was an upward trend in response rate (i.e., higher response rate in the most recent sessions than in former sessions), a phase change was not made (Johnston & Pennypacker, 2009). A slight downward trend was acceptable when moving from Phase 2 to Phase 3, as the target response rate was expected to decrease when reinforcement was not available.
**Phase 3: Renewal.** In Phase 3, the participant returned to Context A. The same instruction as in Phase 1 and 2 was given and the target response remained on extinction. Specifically, both target and control responses were available, but reinforcement was not provided. No toys were available in Phase 3. Phase 3 continued until target responding occurred at a low level, with little to no variability.

**Condition 2.** Following Phases 1, 2, and 3, each participant again experienced a Reinforcement phase in Context A, an Extinction phase in Context B, and a Renewal phase in Context A. Depending on the order of conditions, counterbalanced across participants, Phase 2 in Context B contained two high- or two low-preferred items in each session. Table 3 displays the order of conditions and contexts, randomly assigned prior to the study. If a participant experienced the rich treatment context as Condition 1, with high-preferred toys available in Phase 2, that participant experienced the lean treatment context as Condition 2, with low-preferred toys available in Phase 2.

This experimental design demonstrates experimental control; contingencies remained in place (i.e., extinction continued) across Phases 2 and 3, but the context changed. This allowed for observation of the effects of context change on responding. Additionally, alternating the quality of treatment contexts in Phase 2 between Condition 1 and 2 within participants allowed for a direct comparison of the effects of changes in Phase 2, controlling for intersubject variability (Johnston & Pennypacker, 2009). Finally, the presence of a second, control response box next to the target box throughout phases allowed for separation of relapse effects from general increases in variability. If control responding emerged in Phase 3 in addition to target responding, extraneous factors could be responsible for responding, such as extinction-induced variability. If target responding alone reappeared in Phase 3, it was assumed that renewal occurred.
Inter-Observer Agreement and Treatment Integrity

An independent observer collected data from a video recording following data collection by the primary observer, and recorded frequency of target and control responses, reinforcer deliveries, responses functionally equivalent to the target response, emotional behavior, and duration of toy engagement. Inter-observer agreement (IOA) data were obtained for approximately 47% of sessions for Wade, 35% of sessions for Wanda, and 37% of sessions for Margaret. For duration of toy engagement, IOA was collected for 32% of sessions with toys present for Wade, 34% of sessions with toys present for Wanda, and 34% of sessions with toys present for Margaret. For behaviors measured using frequency, total count IOA was calculated by dividing the smaller of the counts, and multiplying this number by 100 to obtain a percentage. For behaviors measured using duration, total duration IOA was calculated by dividing the smaller of the durations, and multiplying this number by 100 to obtain a percentage. For each participant, the mean IOA was calculated for each behavior. IOA for Wade’s target responding, control responding, reinforcer deliveries, toy engagement, emotional responses, and other functionally equivalent responses were 97.7%, 96.7%, 99.3%, 92.3%, 96.4%, and 94.6%, respectively. IOA for Wanda’s target responding, control responding, reinforcer deliveries, toy engagement, emotional responses, and other functionally equivalent responses were 99.6%, 100%, 99.3%, 69.5%, 96.4%, and 100%, respectively. Notably, mean IOA for Wanda’s toy engagement during the Extinction-Lean phase (62.0%) was lower than mean IOA for Wanda’s toy engagement during the Extinction-Rich phase (99.7%). During these phases, glances at visual toys (e.g., books) were recorded as engagement for Wanda, but poor video quality led to difficulties detecting whether Wanda’s eyes were open and/or if she was engaged with the available items. IOA for Margaret’s target responding, control responding, reinforcer deliveries, toy engagement, emotional
responses, and other functionally equivalent responses were 99.1%, 99.6%, 99.9%,
99.1%, 100%, and 100%, respectively.

Treatment integrity data was collected for 87% of Wade’s sessions, 92% of
Wanda’s sessions, and 35% of Margaret’s sessions. An independent observer
collected data while observing the experimenter or from a video recording, and
recorded whether (a) a preference assessment was conducted at the start of the visit,
(b) the context was assembled correctly, (c) an MSWO was run prior to each
session, (d) the correct instruction was provided to the participant, (e) the
reinforcement schedule was followed as specified in the protocol for each phase
and condition, and (f) reinforcers were never provided following control responses.
Treatment integrity was calculated by dividing the total number of steps
implemented correctly by the total number of steps, multiplying this by 100 to
obtain a percentage, and averaging this percentage across sessions. For Wade’s,
Wanda’s, and Margaret’s sessions, mean treatment integrity was 100%, 99.8%, and
100%, respectively.
Results

Figure 2 displays results for Wade, who experienced the rich condition first. The x-axis shows the session number, with rates of target responding and control responding shown on the primary y-axis, and percentage of time engaged with toys shown on the secondary y-axis. During Phase 1 in Context A (i.e., Reinforcement phase), Wade required 10 sessions to acquire the target response, receiving a mean of 7.75 reinforcers per min throughout. During the final three sessions of the Reinforcement phase, target responding occurred at an average rate of 6.5 responses per min. Throughout the Reinforcement phase, the control response remained at near-zero levels. During Phase 2 in Context B (i.e., Extinction-Rich phase), toy engagement increased, while target responding steadily decreased. Toy engagement occurred for a mean of 71.03% of sessions. Wade’s target responding eventually decreased to zero responses per min across several sessions. Control responding emerged, but remained between 0 and 1 response per min, and did not occur during the final 11 sessions of Phase 2. During the extinction test for renewal by returning to Context A in Phase 3 (i.e., Renewal phase), target responding reemerged. Throughout the Renewal phase, target responding occurred at an average rate of 0.54 responses per min across 11 sessions, reaching a maximum of 3 target responses per min during the seventh session. Additionally, Wade emitted 4.5 responses per min on the control box in the fourth session, but control responding remained at zero levels for the other ten Renewal-phase sessions.

During Phase 4, the experimenter returned to reinforcing target responding while in Context A (Reinforcement). Wade required 20 sessions to reacquire the target response. However, for the first thirteen sessions of the Reinforcement phase, responding did not increase. A brief training session was conducted again, followed by a physical prompt to remain in the seating area, and finally, during session
number 56, one light physical prompt (i.e., manual guidance of Wade’s hand to place the ball in the opening of the target box) was used to increase the likelihood of target responding. Following this session, target responding increased and remained high, ranging from 6 to 10.5 responses per min throughout the remainder of the Reinforcement phase. For the seven sessions during which he responded independently, Wade received a mean of 4.2 reinforcers per min. Target responding occurred at an average rate of 9.8 responses per min during the final three sessions of reinforcement. Control responding occurred between 0.5 and 1.5 responses per min during three sessions of Phase 4, remaining at zero for other sessions. During the Extinction-Lean phase in Context B, toy engagement occurred for a mean of 61.72% of sessions. Although target responding decreased to near-zero levels, Wade consistently emitted 1 target response in each session. He emitted 0.5 control responses per min during two sessions of Phase 5, with control responding at zero for the remaining 14 sessions. During the Renewal phase in Context A, target responding reemerged. Throughout this phase, target responding occurred at an average rate of 0.4 responses per min across 11 sessions, reaching a maximum of 1.5 target responses per min in the fifth session. Finally, Wade emitted 1 response per min on the control box during sessions 3, 4, and 6 during the Renewal phase.

During a return to the rich condition in Phase 7 (Reinforcement), Wade required 7 sessions to reacquire the target response, receiving a mean of 8.7 reinforcers per min. During the final three sessions of the Reinforcement phase, Wade engaged in the target response at a mean of 9.8 responses per min. Control responding did not occur. Throughout the Extinction-Rich phase, toy engagement occurred for a mean of 85.05% of sessions. Target responding occurred throughout this phase (range 0-6 per min), and eventually decreased to one response per session for three consecutive sessions. Control responding occurred at a rate of 0.5 per min during the 11th session of Phase 8, remaining at 0 responses per min for the
duration of this phase. During the Renewal phase, target responding reemerged, at a rate of 1 response per min in the first session. Throughout this phase, target responding occurred at an average rate of 2.1 responses per min across 11 sessions, reaching a maximum of 5.5 target responses in the 11th session of Phase 9. Control responding occurred at low rates, ranging from 0-2 responses per min, and remaining at 0 levels for the final three sessions.

During Wade’s second exposure to the lean condition, he required 6 sessions to acquire the target response in the Reinforcement phase, receiving a mean of 5.1 reinforcers per min. In the final three sessions of the Reinforcement phase, Wade engaged in the target response at a mean of 11 responses per min. Control responding did not occur. During the Extinction-Lean phase, toy engagement occurred for a mean of 88.67% of sessions. Target responding occurred at low rates for the first six sessions, steadily decreasing to zero levels for the final three sessions. Control responding emerged in the second session of Phase 11, but occurred at zero levels for the final three sessions, as well. During Phase 12, the Renewal phase, target responding reemerged at a maximum rate of 2.5 responses per min during the first session. Throughout the Renewal phase, target responding occurred at an average rate of 0.4 responses per min. Control responding reemerged, as well, but remained at low levels (range 0-1.5 per min) throughout the final phase.

Figure 3 displays Wade’s Phase 3, 6, 9, and 12 (Renewal phases) target responding rates, converted to proportions of mean rate of target responding during the final three sessions of each Reinforcement phase (i.e., Phases 1, 4, 7, and 10). Calculation and comparison of the proportion of Reinforcement-phase rates of responding in the Renewal phases controlled for any differences in Reinforcement-phase response rates between the rich and lean conditions. Proportions of Reinforcement-phase responding in Renewal phases were calculated by dividing
the rate of target responding in each Renewal session by the mean rate of target responding during the final three sessions of the preceding Reinforcement phase.

For Wade, following both exposures to the rich condition (i.e., presence of high-preferred toys in Context B, followed by withdrawal of high-preferred toys in Context A), the proportion of target responding was greater than in the lean condition. Wade’s target responding for the final three sessions of each Reinforcement phase occurred at means of 6.5, 9.8, 9.8, and 11 responses per min. During the first exposure to the rich condition, proportion of target responding in Renewal ranged from 0-0.46, with a mean of 0.08. During the second exposure to the rich condition, proportion of target responding in Renewal ranged from 0.05-0.55, with a mean of 0.21. During the first exposure to the lean condition, proportion of target responding in Renewal ranged from 0-0.15, with a mean of 0.04. During the second exposure to the lean condition, proportion of target responding in Renewal ranged from 0-0.22, with a mean of 0.04.

Figure 4 displays results for Wanda, who experienced the lean condition first. During her first exposure to the Reinforcement phase in Context A, she required 11 sessions to acquire the target response, receiving a mean of 4.3 reinforcers per min. Target responding occurred at an average of 11.83 responses per min during the final three sessions of the Reinforcement phase. During the Extinction-Lean phase in Context B, target responding appeared to increase for the first 20 sessions, decreasing during the final three sessions. Toy engagement occurred for a mean of 31.49% of sessions, occurring at a high percentage of the session (95.42%) during only the 22nd session. Most of Wanda’s toy engagement during the Extinction-Lean phase was limited to glancing at or touching the available items. During the Renewal phase in Context A, target responding occurred at an average rate of 9.98 responses per min across 20 sessions, reaching a
maximum of 18 target responses per min during the eighth session. Throughout the lean condition, Wanda did not engage in control responding.

During Phase 4, the experimenter returned to reinforcing Wanda’s target responses while in Context A. Wanda required 17 sessions to reacquire the target response, receiving a mean of 6.5 reinforcers per min. Target responding occurred at an average of 20.67 responses per min during the final three sessions of the Reinforcement phase. During the Extinction-Rich phase in Context B, target responding immediately decreased to zero responses per min, and remained at 0.5 responses per min for the following five sessions. Toy engagement immediately increased, and occurred at a mean of 99.1% of sessions. Finally, during the Renewal phase, Wanda’s target responding occurred at an average rate of 10.18 responses per min across 20 sessions, reaching a maximum of 14 target responses per min during the second session. Throughout the rich condition, Wanda did not engage in control responding.

Figure 5 shows Wanda’s Phase 3 and 6 (Renewal) target responding rates, converted to proportions of mean rate of target responding during the final three sessions of each Reinforcement phase (i.e., Phases 1 and 4). For Wanda, following an exposure to the lean condition, the proportion of target responding was greater than in the rich condition, for 16 of 20 sessions. Wanda’s target responding for the final three sessions of each Reinforcement phase occurred at means of 11.83 and 20.67. During the lean condition, proportion of target responding in Renewal ranged from 0.34-1.52 with a mean of 0.84. During the rich condition, proportion of target responding in Renewal ranged from 0.15-0.68, with a mean of 0.49.

Figure 6 displays results for Margaret, who experienced the rich condition first. During her first exposure to the Reinforcement phase in Context A, she required three sessions to acquire the target response, receiving a mean of 22.3
reinforcers per min. Target responding occurred at an average of 22.7 responses per min during these three sessions. Control responding did not occur. During the Extinction-Rich phase in Context B, target responding decreased after the first three sessions, eventually occurring at a low, steady rate of 2-3 responses per min. Control responding emerged during the 10th session and occurred at a rate similar to target responding throughout the remainder of the phase. Toy engagement occurred for a mean of 57.2% of sessions, eventually occurring at high, steady percentages. During the Renewal phase in Context A, target and control responding reemerged at similar rates (ranges 11-14 responses per min). Rates of target and control responding did not decrease significantly throughout this phase, but eventually reached stability.

During Phase 4, the experimenter returned to reinforcing target responding while in Context A. She required six sessions to reacquire the target response, receiving a mean of 13.58 reinforcers per min. During the first two sessions of the Reinforcement phase, however, Margaret emitted both target and control responses, therefore, the experimenter conducted an additional training session prior to the third session. During the training session, Margaret was instructed, “Do this,” and the experimenter modeled the target response. Ten consecutive, independent responses on the target box concluded the training session. Following this, zero control responses were emitted throughout this phase. During the final three sessions of the Reinforcement phase, target responding occurred at an average of 32 responses per min. During the Extinction-Lean phase, target responding gradually decreased, and control responding occurred during sessions 2, 8, 9, and 10. Margaret did not engage with the available low-preferred toys throughout this phase; toy engagement occurred for 0% of sessions. During the Renewal phase, target responding reemerged at high rates, with 28 target responses per min during the first session, decreasing slightly but remaining high (range 20.5-29 responses...
per min). Control responding did not reemerge, but occurred at a rate of 0.5 responses per min during the 10th session.

Figure 7 displays Margaret’s Renewal-phase (i.e., Phases 3 and 6) target responding rates, converted to proportions of mean rate of target responding during the final three sessions of each Reinforcement phase (i.e., Phases 1 and 4). For Margaret, following an exposure to the lean condition (i.e., presence of low-preferred toys in Context B followed by withdrawal of low-preferred toys in Context A), the proportion of target responding was greater than in the rich condition. Margaret’s target responding for the final three sessions of each Reinforcement phase occurred at means of 22.7 and 32. During the rich condition, following withdrawal of high-preferred items, proportion of target responding in Renewal ranged from 0.49-0.64, with a mean of 0.57. During the lean condition, following withdrawal of low-preferred items Margaret had not engaged with, proportion of target responding in Renewal ranged from 0.64-0.91, with a mean of 0.76.
The present study compared ABA renewal between an enriched treatment context and a leaner treatment context, using qualitatively different toys to simulate these conditions. Across all participants, there were no systematic effects of these conditions on target responding during the tests for renewal. In one participant, Wade, effects of the quality of the treatment context on renewal were clear throughout his participation in the study, and greater renewal was observed during the rich conditions. Recommendations for learners similar to Wade, for whom quality of treatment context plays a potential role in mitigation of treatment relapse, will be discussed.

For participants Margaret and Wanda, however, variables other than the different treatment contexts seemed to influence rates of target responding during the Extinction-Lean and Renewal phases. For Margaret, the emergence of responses on the object permanence box designated to act as a control response with no associated history of reinforcement suggests reemergence of target responding in the Renewal phase cannot be assumed to be directly a function of the history of reinforcement. Increases in control responding are in contrast to previous demonstrations of relapse being specific to target responding (e.g., Craig & Shahan, 2016; but see Sweeney & Shahan, 2016). Moreover, extinction and availability of the low-preferred items did not reliably eliminate target response rates for these participants. These unexpected outcomes will be discussed with regard to variables influencing choice (Cuvo, Lerch, Leurquin, Gaffaney, & Poppen, 1998; Zhou, Goff, and Iwata, 2000), general increases in variability due to extinction (Neuringer & Jensen, 2013), limited exposure to Reinforcement (Shahan & Sweeney, 2016; Todd, Winterbauer, and Bouton, 2012), and discrimination issues. Finally,
implications of these results pertinent to translational and applied research regarding behaviors targeted for reduction will be discussed.

**Effects of Enriched Treatment Contexts on Renewal**

Wade’s target and control responding, levels of toy engagement, and reemergence of target responding supported our hypotheses, and lent support to past research investigating treatment relapse. His rates of target responding increased during Reinforcement phases, and rates of target responding decreased during Extinction phases when toys were available, during both rich and lean conditions. Control responding emerged, but it did not rise to rates comparable with target responding, and decreased upon reintroduction of reinforcement for target responses. Further, Wade’s target responding reemerged at greater magnitudes in the rich conditions than in the lean conditions, supporting the conclusions of prior studies suggesting that the withdrawal of more favorable conditions leads to greater and more intense relapse (Craig & Shahan, 2016; Craig, Browning, Nall, Marshal, & Shahan, 2017; Leitenberg, Rawson, & Mulick, 1975; Shahan & Sweeney, 2013). Although these effects are attributed to renewal and the quality of the treatment context, due to the experimental arrangements in the present study, experimenters cannot dismiss the possible role of resurgence.

Previous resurgence studies simulated rich and lean treatment contexts through manipulation of reinforcement rate. However, the potential for a slightly different mechanism governing greater relapse in Wade’s rich condition exists. In a study with rats, Craig et al. (2017) introduced a unique resurgence procedure by manipulating the magnitude of the reinforcer delivered for alternative responding across phases 2 and 3. Experimenters observed greater relapse following a larger reduction of alternative reinforcement, i.e., the shift from delivery of six reinforcers to the delivery of zero reinforcers, and observed less relapse following a smaller
reduction of alternative reinforcement, i.e., the shift from delivery of six reinforcers to the delivery of three reinforcers. Thus, resurgence was mitigated by decreasing magnitude of alternative reinforcement across phases, rather than completely withdrawing alternative reinforcement, as seen in typical resurgence arrangements. This decrement in quality of treatment context in the transition to the relapse test phase aligns with Wade’s results from the present study. The shift from a high quality treatment context to extinction with no available leisure items could be viewed as analogous to withdrawal of greater magnitude, leading to more relapse as observed by Craig et al. and with Wade. Alternately, the shift from a low-quality treatment context to extinction with no available leisure items could be viewed as analogous to milder withdrawal of reinforcement, leading to less relapse.

Superimposing our results onto an applied scenario, systematically decreasing the richness of the environment across contexts could mitigate relapse effects upon a return to the context of learning. For example, for a child who engages in problem behavior, e.g., aggression, at school, a therapist might first provide him/her with a tablet during treatment sessions. If no leisure items are available to the child at school, he/she might engage in high rates of aggression. However, if the child is provided a moderately preferred toy, e.g., a racecar, during treatment sessions, he/she might engage in relatively low rates of aggression when leisure items are unavailable at school.

Wade’s results support the premise that removal of more favorable conditions leads to greater relapse, therefore, additional recommendations for the treatment environment could be made. Although treatment effects may be rapid and intense in high-quality treatment environments, this may not lead to long-lasting behavior change across environments. Bowman, Piazza, Fisher, Hagopian, and Kogan (1997) demonstrated that varying presentation of less-preferred reinforcers competed effectively with constant presentation of the highest preferred reinforcer
in more than half of participants. Francisco, Borrero, and Sy (2008) demonstrated that when high-preferred and low-preferred edible items were presented concurrently, child participants engaged in the response that would produce the high-preferred edible, but for some participants, when the low-preferred choice was presented alone, moderate levels of the target response were maintained. Their results suggest that when a high-preferred stimulus is not available, delivery of a low-preferred stimulus can support moderate rates of responding. It is important to note, however, that the low-preferred stimuli used by Francisco, Borrero, and Sy were not the absolute lowest ranked stimuli, as in the present study. Rather, stimuli used were those selected on 22% of opportunities during the preference assessment, as it was unlikely participants would allocate responding toward the response signaling the absolute lowest ranked stimulus. These examples of less potent reinforcers producing similar effects as the most potent reinforcers suggests that if the desired treatment effects can be reached using slightly lower quality stimuli, this is a valid approach for some individuals. Further, as previously discussed, for learners similar to Wade, the presence of lower quality stimuli could lead to less relapse. Overall, a moderate-quality treatment environment could be sufficient to produce treatment effects and support maintenance and generalization across environments.

**Enriched Treatment Contexts and Target Responding**

Similar recommendations cannot be made for Margaret and Wanda, whose data do not clearly align with past research examining the effects of treatment-context quality on relapse. The enrichment in our simulated treatment context was intended to represent stimuli available during behavior-reduction treatments in a clinic setting. However, enriched treatment contexts may not be sufficient to eliminate problem behavior, or to promote maintenance and generality across settings, especially if extinction does not result in reduction of the target behavior.
For both Margaret and Wanda, greater relapse was observed following exposure to the leaner treatment context, demonstrated by rate and proportion of target responding during Renewal phases. However, these results do not suggest a clear effect of quality of treatment context or relapse, due to extraneous variables and unexpected trends in responding. During Margaret’s Extinction-Rich phase, after several sessions, target responding decreased to low, stable rates, while toy engagement increased to high, stable levels. However, unexpectedly, during the Extinction-Lean phase, despite prior exposure to extinction contingencies with toys available, response rates did not reach low levels, and control responding reemerged and occurred at rates similar to target responding. During Wanda’s Extinction-Rich phase, target responding immediately decreased, while toy engagement immediately increased to high, stable levels. During Wanda’s Extinction-Lean phase, however, toy engagement was limited to occasional glances and touches, while target responding persisted. These findings confirmed that enriched contexts initially lead to greater reduction of target responding. However, specific behavioral processes involved are unclear due to increased control responding, as well as the lack of systematic decrease of target responding in the lean condition.

In another experiment by Craig et al. (2017), they further elaborated on this suppression in a resurgence procedure examining the effects of varying magnitudes of alternative reinforcement in rats. Specifically, an alternative response was trained in Phase 2 and magnitude of reinforcement varied across groups. Of the three groups, two were most relevant to the present study. One group was randomly assigned to receive five pellets per reinforcer delivery following alternative-response lever presses, analogous to a rich treatment context. Another group was randomly assigned to receive one pellet per reinforcer delivery following alternative-response lever presses, analogous to a lean treatment context. During
Phase 2, responding on the two levers (target and alternative) was variable for the one-pellet group and target responding decreased gradually, while target responding decreased rapidly and occurred at a lower rate for the five-pellet group. Phase-2 patterns of responding provide a precedent for the disparity between the Extinction-Lean and Extinction-Rich phases for Margaret and Wanda – leaner treatments appear to produce greater levels of variability in target behavior.

Further, Craig et al. (2017) found that discontinuing the larger magnitude alternative reinforcer led to resurgence of the target behavior, but discontinuing the smaller magnitude alternative reinforcer did not. In the present study, target responding for Margaret and Wanda reemerged at higher rates following the Extinction-Lean phase, or withdrawal of less favorable conditions. High- and low-preferred tangible items were available during the treatment phases, but perhaps simulating the quality of the treatment contexts by manipulating the duration of access to a highly preferred tangible item would have produced effects similar to those observed by Craig et al.

The Role of Choice

Further conceptualizing the behavior of Margaret and Wanda during the Extinction-Lean phase, when provided a choice between engaging in a low response effort task that had a history of reinforcement (target response) and engaging with a low-preferred toy with no history of reinforcement, these participants chose the low-effort task of placing the ball in the target box. The matching law suggests that individuals’ behavior will be allocated toward richer sources of reinforcement (Herrnstein, 1970). When a single ball and two object permanence boxes were available during the Reinforcement phase in the present study, participants were more likely to place the ball in the object permanence box producing reinforcement and not in the control box. Based on the matching law, it
was expected that when the response-reinforcer relation for target responding was discontinued during extinction, the target response would decrease. Although target responding decreased between the Reinforcement phases and the end of the Extinction-Lean phases, Margaret’s and Wanda’s target responding nevertheless persisted far above near-zero levels when reinforcement was discontinued in the Extinction-Lean condition, and in the Renewal phases. One explanation for this phenomenon is that the response of placing the ball in the target box had a history of reinforcement, and required relatively low response effort.

In the present study, high-preferred and low-preferred toys were not concurrently available. Nevertheless, previous literature examining concurrently available schedules of reinforcement can elucidate behavioral effects observed in the present study. Zhou, Goff, and Iwata (2000) manipulated the response effort required to engage in self-injurious behavior, and found that participants were more likely to engage with an object (i.e., less-preferred reinforcer) when the target behavior was more difficult to emit. However, when the target behavior (self-injurious behavior) required less response effort to emit, participants were less likely to engage with available objects. Cuvo, Lerch, Leurquin, Gaffaney, & Poppen (1998) assessed the conditions under which participants would choose tasks associated with low response effort or tasks associated with high response effort. Findings from Experiment 1 showed that participants allocated responding toward richer schedules of reinforcement, which equated to less work. In Experiments 2 and 3, participants were required to engage in physical work to access reinforcement, specifically, a distant beanbag toss versus a proximal beanbag toss, and jumping over hurdles of varying heights. Participants allocated responding to the choice signifying less response effort (the closer toss or shorter jump) when schedules of reinforcement were equivalent. When the schedule of reinforcement for the response requiring less response effort was thinned,
responding was allocated to the richer schedule of reinforcement, signified by the response that required more response effort (the farther toss or higher jump). These studies demonstrate that individuals allocate responding toward reinforcement, and this can be extrapolated to include responses with past histories of reinforcement. Specifically, individuals will reallocate responding from responses requiring less response effort with thin schedules of reinforcement to responses requiring more response effort with dense schedules of reinforcement.

Differences in target responding observed between the Extinction-Rich and Extinction-Lean phases for Margaret and Wanda support the conclusions of Zhou et al. (2000) that despite the availability of leisure items, additional methods are required to reduce target behavior, such as increased response effort. During the Extinction-Lean condition, response effort for the target response remained low. Addition of reinforcement contingent on engagement with low-preferred toys (e.g., a puzzle for Margaret, a book for Wanda) may have been necessary to increase Margaret and Wanda’s low-preferred toy engagement. These differences align with the findings of Cuvo et al. (1998), as well. Although the rich and lean treatment contexts were not presented as a choice for Margaret and Wanda, experimenters observed that rates of the low effort response, i.e., target responding, were high in the Extinction-Lean phase, but in the Extinction-Rich phase, both participants engaged in high-effort responses, e.g., drawing in a sketchbook, navigating an iPad, to access reinforcement using preferred toys. Factors influencing choice provided by Zhou et al. and Cuvo et al. provide a rationale for Margaret and Wanda’s persistent target responding, as this response was associated with a history of reinforcement.
**Extinction-Induced Variability**

Beyond the history of reinforcement associated with target responding, emitting target and/or control responses may have been automatically reinforcing for Margaret. While Wanda never engaged in responses on the control box, Margaret emitted responses on the control box, even though these responses had never been reinforced. This suggests the role of variables beyond history of reinforcement and response effort. Margaret’s emergent responding on the control box during the Extinction-Rich phase suggests an increase in general variability. Further, control responding persisted during her first exposure to the first Renewal phase. Sweeney and Shahan (2016) conducted a study with college student participants, in which a choice between a computerized target, alternative, and “inactive” response was required. Across participants, there was little difference between target and inactive responding during the tests for relapse. This study highlighted the importance of including an inactive (i.e., control) response to assess general increases in variability, as opposed to relapse alone. In our study, the control (green) object permanence box functioned as a control for varying histories of reinforcement for different responses, and allowed for separation of relapse and variability.

Based on the arrangement of response options, one explanation for the emergence of Margaret’s control responding is extinction-induced variability (Neuringer & Jensen, 2013). Extinction of a response may occasion several behavioral effects, including increases in variability of responding. For example, if one solution to a problem is ineffective, an individual will try other methods. When Margaret was exposed to the extinction contingency for several sessions, it is possible that she attempted to access edible reinforcement by emitting a different response than the target response. The control response was in the same topographical response class as the target response. According to Neuringer and
Jensen, variations produced by extinction generally emerge from the originally learned response class, supporting the premise that the control response emerged due to extinction-induced variability.

**Exposure to Reinforcement**

Notably, Margaret is a typically developing adolescent, and likely had a lengthy history of reinforcement for variable responding prior to this study. Upon exposure to the second Reinforcement phase, Margaret’s responding on the control box persisted. Despite differential reinforcement of the target response, both target and control responding increased slightly during the first two sessions of the second Reinforcement phase. Margaret responded rapidly, with alternating responses distributed almost evenly on both boxes. This contiguity likely led to unintentional reinforcement of chained responses on the target and control boxes. Margaret’s control responding represents a potential lack of discrimination between the target and control boxes. During the first Reinforcement phase, Margaret required three sessions to acquire the target response, a relatively short period of exposure to reinforcement for the target response. Following the first two sessions of the second Reinforcement phase, Margaret experienced an additional training phase, i.e., she was trained to respond on the target box using a model prompt and an FR-1 schedule of reinforcement, until ten consecutive independent target responses were emitted, identical to the training phase prior to the study. Subsequently, she required four additional sessions to reacquire the target response, responding at higher rates than during the first Reinforcement phase. Throughout the remainder of the study, Margaret’s target responding persisted at high rates, while control responding did not consistently reemerge at high rates. This suggests Margaret discriminated between the target and control boxes following additional exposure to reinforcement for the target response.
Importantly, both Margaret and Wanda emitted higher rates of target responding during the second exposure to the Reinforcement phase than in the first Reinforcement phase. However, Wanda experienced longer exposures to both Reinforcement phases than Margaret, and throughout the study, Wanda never emitted a single response on the control box. This suggests that discrimination issues might be resolved or prevented by increased exposure to reinforcement of the target response (Sweeney & Shahan, 2016; Todd, Winterbauer, & Bouton, 2012). Specifically, Todd et al. demonstrated greater intensity and magnitude of ABA renewal by increasing the amount of time and number of sessions for which groups of rats’ target responses were exposed to reinforcement. Their findings suggest that due to the context specific nature of renewal, extensive training in Context A, leading to higher initial rates of responding, is likely to precede greater renewal in the same context. Perhaps if Margaret had received increased exposure to sessions in the Reinforcement phases, discrimination between the target and control responses would have occurred, and/or renewal would have been observed rather than responses attributed to extinction-induced variability. Extensive training in the Reinforcement context is representative of long histories of reinforcement for problem behavior prior to extinction in another setting, e.g., a therapy clinic. Therefore, longer periods of reinforcement more closely simulate natural conditions.

In addition to potential lack of discrimination between the target and control responses, following the study, Margaret reported a lack of discrimination between the two color-coded contexts. More specifically, she stated that she did not notice that within the same visit, the experimenter was wearing different colored shirts. However, during the preference assessment on Margaret’s second day of exposure to the Extinction-Lean phase, she commented that she wanted to rank her high-preferred toys as least preferred because she knew that her low-preferred toys
would be available during sessions. Additionally, Margaret reported observing that the experimenter had “[taken] away” snacks, and knowing when she was able to earn snacks again, suggesting awareness of the contingencies in place during sessions. However, the color-coded contexts likely did not serve as discriminative stimuli signaling the availability or unavailability of reinforcement for the target response. Perhaps providing a rule, e.g., “Now everything is blue, you can earn snacks,” or issuing a brief statement drawing Margaret’s attention to the colors, thereby signaling the context change, e.g., “Did you notice that everything is red?” would have influenced Margaret’s responding.

**Future Directions**

Future studies could incorporate other changes into studies assessing the effects of treatment context quality on renewal, as well. A pre-assessment of target response rates during exposure to reinforcement could be conducted, to decrease differences in rates of target responding between Reinforcement phases within participants, or the Reinforcement phase could occur for a fixed, predetermined number of sessions. Further, experimenters should ensure that target responding decreases in the treatment context; in a therapy setting, therapists would not likely continue to present a stimulus a child did not interact with during behavioral therapy sessions. As recommended by Francisco, Borrero, and Sy (2008), items chosen during some percentage of opportunities could be provided. Finally, some laboratory studies with nonhuman animals arrange varying topographies as options for different responses, e.g., a lever press as a target response, and a chain pull as an alternative response. The control response available in future studies could be a response of a different topography, e.g., pushing a button, potentially to reduce extinction-induced variability with regard to history of reinforcement for the target response topography. A control response of a different topography than the target response might increase discriminability between responses, as well. To increase
discriminability between contexts, different contexts could be located in different rooms, as well.

**Conclusion**

The present study investigated the effects of the quality of the treatment context on renewal. Findings for one participant supported the hypothesis and previous resurgence literature suggesting that withdrawal of more favorable conditions leads to greater relapse. However, findings from two participants suggest that response effort and/or extinction-induced variability play an important role in interpreting results of translational studies investigating treatment relapse. Mace and Critchfield (2010) state the importance of evaluating the interspecies generality of basic research findings. Mixed results from the present study underscore the necessity for translational research to bridge the gap between basic-research findings and problems of social significance in humans. Specifically, these findings highlight the necessity for additional translational research investigating renewal, if inferences are to be made regarding clinical treatment relapse.

Nevertheless, each outcome provides information relevant to behavior reduction treatments conducted in applied settings, as practitioners must ensure generalization of behavioral treatment effects across settings. While some individuals require high-quality treatment environments to ensure behavior reduction, others require only moderate-quality treatment environments, and some might require additional modifications, e.g., higher response effort required for the target response. Research investigating relapse and treatment conditions in the applied sector with behaviors of social significance should be conducted in order to establish clinical recommendations. By gaining an understanding of the effects context and quality of treatment conditions have on relapse, clinicians can better
plan treatments to decrease potential relapse, and better communicate with individuals responsible for maintaining treatments in natural environments.
References


Table 1

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Note. Table 1 depicts the key conditions used by Podlesnik and Kelley (2014) in Modified resurgence and Renewal control conditions. VI 60-s = Variable-Interval 60-s schedule of reinforcement, EXT = Extinction.
Table 2

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<tr>
<td>A</td>
<td>VR2</td>
<td>No</td>
<td>No toy</td>
<td>No toy</td>
<td>VR2</td>
<td>No</td>
<td>No toy</td>
</tr>
<tr>
<td>B</td>
<td>EXT</td>
<td>No</td>
<td>High-preferred toy</td>
<td>No toy</td>
<td>EXT</td>
<td>No</td>
<td>Low-preferred toy</td>
</tr>
<tr>
<td>A</td>
<td>EXT</td>
<td>No</td>
<td>No toy</td>
<td>No toy</td>
<td>EXT</td>
<td>No</td>
<td>No toy</td>
</tr>
</tbody>
</table>

Note. Table 2 describes the contexts, contingencies, and presence of toys in each condition. VR 2 = Variable-Ratio 2 schedule of reinforcement, EXT = Extinction
Table 3

<table>
<thead>
<tr>
<th>Color-coding</th>
<th>Condition order</th>
<th>Target position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wade</td>
<td>A = Red, B = Blue</td>
<td>Rich, Lean</td>
</tr>
<tr>
<td>Wanda</td>
<td>A = Blue, B = Red</td>
<td>Lean, Rich</td>
</tr>
<tr>
<td>Margaret</td>
<td>A = Blue, B = Red</td>
<td>Rich, Lean</td>
</tr>
</tbody>
</table>

*Note.* Table 3 depicts the counterbalancing of color-coded contexts, condition orders, and box positions across participants.
Figure 1. Figure 1 depicts a Montessori object permanence box, shown here in natural wood.
Figure 2. Figure 2 depicts the two color-coded contextual arrangements, including the experimenter’s shirt, the clipboard, pen, timer, plate, and placemat. For Wade and Wanda, the chairs were color-coded, as well.
Figure 3. Figure 3 displays rates of responding and toy engagement for Wade. (RFT = Reinforcement of target response on VR 2 schedule of reinforcement, EXT = Extinction of target response, RICH = High-preferred toys available, LEAN = Low-preferred toys available, RNW = test for renewal)
Figure 4. Figure 4 displays Wade’s target responding during Renewal (Phases 3, 6, 9, and 12) as a proportion of target responding during Reinforcement (Phases 1, 4, 7, and 10).
Figure 5. Figure 5 displays rates of responding and toy engagement for Wanda.
Figure 6. Figure 6 displays Wanda’s target responding during Renewal (Phases 3 and 6) as a proportion of target responding during Reinforcement (Phases 1 and 4).
Figure 7. Figure 7 displays rates of responding and toy engagement for Margaret.
Figure 8. Figure 8 displays Margaret’s target responding during Renewal (Phases 3 and 6) as a proportion of target responding during Reinforcement (Phases 1 and 4).