Assessing the Combined Effects of Resurgence and Renewal

by

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Abstract

Title: Assessing the Combined Effects of Resurgence and Renewal

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Resurgence and renewal are laboratory models of treatment relapse revealing the effects of treatment integrity errors and context change on problem behavior eliminated through treatment with differential reinforcement of alternative behavior (DRA). This study used translational methods to assess the effects of context change after DRA (renewal) with and without extinction in the form of treatment integrity errors (resurgence) on relapse in children with autism. In Phase 1 and in Context A, we trained an arbitrary target response. In Phase 2 and in Context B, we extinguished the target response and reinforced an alternative response. Phase 3 tested for relapse when the participant was returned to the original context (A). In one Phase 3 condition (100%), DRA treatment was continued as in Phase 2. In the other condition (0%) the participant was exposed to extinction of alternative responding, modeling errors of omission. For two of three participants, renewal of target responding was observed in the 100% condition, and for all participants, resurgence of target responding was greater in the 0% condition compared to the 100% condition. This study revealed resurgence of target behavior is greater when context change is combined with breakdowns in treatment integrity.
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Dedication

I dedicate this thesis to my husband, Daniel. Thank you for your unconditional love and support.
Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder characterized by deficits in social interaction and communication, and by restricted and repetitive patterns of behavior (World Health Organization, 1992). Children diagnosed with ASD often exhibit problem behavior, including disruption, self-injury, and aggression. Applied behavior analysis (ABA) uses a set of empirically validated procedures to teach new skills and address problem behaviors.

Differential Reinforcement and DRA

One of the most common classes of procedures used in applied settings to reduce the frequency of problematic behavior is differential reinforcement (Petscher, Rey, & Bailey, 2009; Vollmer & Iwata, 1992). Differential reinforcement procedures use contingent reinforcement of some topography, frequency, magnitude, or other dimension of behavior (Vollmer & Iwata, 1992). One of the most frequently used procedures in this class is DRA, or differential reinforcement of alternative behavior (Petscher et al., 2009). These interventions involve reinforcing an alternative, more acceptable means of obtaining the same reinforcer as that maintaining the targeted behavior (Volkert, Lerman, Call, & Trosclair-Lasserre, 2009). As both the target and alternative behavior can be reinforced and maintained by access to the same stimulus or event, they are equivalent in function (Iwata, Pace, Cowdrey, & Miltenberger, 1994; Tiger, Hanley, & Bruzek, 2008). For example, if throwing assigned worksheets on the floor and asking for a break both result in temporary escape from assigned tasks,
they are functionally equivalent; a DRA intervention to address this disruptive classroom behavior might involve reinforcing appropriate requests for breaks. Identification of the maintaining function of the problem behavior therefore aids the implementation of DRA, because it can guide the selection of an effective alternative behavior to reinforce (Athens & Vollmer, 2010). In addition to reinforcing an appropriate alternative behavior, DRA procedures often implement extinction. (Athens & Vollmer, 2010; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009). Extinction procedures are those in which the reinforcer for the target behavior is withheld (Bouton, Winterbauer, & Todd, 2012; Vollmer, Roane, Ringdahl, & Marcus, 1999). By teaching and reinforcing an alternative response while placing the target problem behavior on extinction, DRA allows the individual to contact reinforcement in a more socially acceptable manner, an advantage in comparison to extinction-only procedures (Epstein, 1983; Leitenberg, Rawson, & Bath, 1970; Vollmer & Iwata, 1992).

Functional communication training (FCT), a type of DRA procedure in which the alternative behavior is communicative in nature, has been established as an effective intervention for problem behavior (Carr & Durand, 1985). This procedure focuses on teaching an individual to emit an appropriate request (i.e. mand) as an alternative to engaging in problem behavior. Participants were four children with developmental disabilities whose problem behavior was maintained by attention. They were taught to request praise and attention from the instructor, and one participant whose problem behavior was maintained by escape from
difficult tasks was taught to request a break. Reinforcing appropriate requests for the same consequence that maintained problem behavior resulted in a reduction in problem behavior and an increase in appropriate requests.

**Treatment Relapse**

DRA procedures, including FCT, are widely adopted and empirically validated means of reducing problem behavior while teaching alternative behavior, but are susceptible to treatment relapse (Volkert et al. 2009, Petscher et al., 2009). Relapse of problem behavior after effective treatment is an issue continually faced by behavior analysts, and is problematic in that it often leads to use of more restrictive procedures and placement (Pritchard, Hoerger, & Mace, 2014). Treatment relapse has been extensively studied in basic research with nonhumans but is also of applied significance for clinicians working with humans (Winterbauer & Bouton, 2012). The socially significant behavior changes studied by applied researchers can be considered effective to the extent that they are maintained across contexts and over time (Bloom & Lambert, 2015; Stokes & Baer, 1977). However, behaviors targeted for reduction with DRA are unfortunately prone to relapse. The susceptibility of behaviors treated with DRA to treatment relapse has been noted extensively by clinicians and practitioners and evaluated in applied research (Wacker et al., 2013; Lieving, Hagopian, Long & O’Connor, 2004; Volkert et al., 2009).
**Treatment Integrity Errors**

In applied settings, treatment relapse may result from treatment integrity errors, which occur when a procedure is not implemented as it is designed. In the case of DRA, this often involves either providing reinforcement for extinguished target behavior (errors of commission) or withholding reinforcement for alternative behavior (errors of omission; St. Peter Pipkin, Vollmer, & Sloman, 2010). The proposed investigation will focus on the unintended exposure to extinction that occurs with errors of omission. Breakdowns in treatment integrity, including errors of omission, pose problems for the long-term efficacy and maintenance of DRA interventions, and have been demonstrated to have a significant impact on the outcome of behavioral interventions (Durand & Carr 1991, Vollmer et al., 1999; St. Peter Pipkin, Vollmer, and Sloman, 2010, Groskreutz et al., 2011, Pence & St. Peter, 2015). For example, Durand and Carr (1991) used FCT to teach a participant to request assistance by saying “I don’t understand,” resulting in a decrease in targeted self-injurious behavior, but rates of the problem behavior increased above pre-treatment levels when the poorly articulated request was not reinforced by a new teacher. The new teacher’s errors of omission in implementing reinforcement of alternative responding resulted in unintended extinction of the requesting response, and resurgence of the extinguished problem behavior. The literature on the effects of reduced treatment integrity on behavioral relapse in DRA indicates that high levels of treatment integrity in the teaching and reinforcement of
alternative responses are integral to the maintenance of these treatments (Vollmer et al. 1999; Bloom & Lambert, 2015).

**Resurgence**

One model of treatment relapse that is directly relevant to treatment integrity errors in DRA is resurgence (Lieving et al., 2004). Resurgence occurs when a previously extinguished response reemerges during extinction of another response currently in the repertoire (Podlesnik & Kelley, 2014). In other words, problem behavior often returns when alternative responses are not consistently reinforced, or are placed on extinction, as in the case of errors of omission. (Volkert et al., 2009). Resurgence effects help to explain how contingency changes in the form of omission errors may impact the outcome of behavioral procedures such as DRA (Winterbauer, Lucke, & Bouton, 2013).

Resurgence is typically tested in a three-phase procedure (Leitenberg, Rawson & Bath, 1970; Volkert et al., 2009). Volkert et al. provides a model of how this three-phase procedure is often carried out. The authors evaluated the occurrence of resurgence for three young participants with developmental disabilities who received treatment with FCT for problem behaviors including self-injury, aggression, and disruption. Phase 1 consists of reinforcement of the target response. The authors determined through functional analysis that each child’s problem behavior was at least partially socially maintained, in that it occurred most frequently when followed by either attention, access to toys possessed by adults, or escape from demands. In Phase 1, the social reinforcer was provided contingent on
every occurrence of the targeted problem behavior. For example, in this phase, for participants whose aggression was maintained by escape from demands, a break was provided whenever aggression occurred. In Phase 2, the target response was placed on extinction and an alternative response was reinforced, in that each participant was taught to request the reinforcer that had been found to maintain problem behavior (a break, attention, or toy). In Phase 3, the target response and the alternative response were both placed on extinction, in that neither contacted reinforcement. In this phase, neither problem behavior nor asking for a break, attention, or toy resulted in getting what was requested, modeling omission errors. Resurgence of problem behavior was observed for two of the three children who participated in this experiment, in that rates of problem behavior increased during the first and second implementations of Phase 3. These results provide support for the role of resurgence in cases of treatment relapse after DRA/FCT procedures when used to reduce socially significant behavior problems in humans.

Nonetheless, the bulk of investigations in the resurgence literature involve laboratory procedures with nonhuman animals, or basic research. For example, Winterbauer and Bouton (2010) investigated resurgence during the extinction of lever pressing in rats. Rats were trained to press one lever (L1) for food pellets in Phase 1. The rats were then trained to press a second lever (L2) for food while L1 pressing was placed on extinction in Phase 2. In Phase 3, the rats were tested under conditions of extinction for both L1 and L2 pressing. Resurgence was observed in
that L1 pressing rates increase above Phase 2 levels, once rats’ lever pressing was exposed to extinction of both L1 and L2 in Phase 3.

Such procedures, developed and tested in laboratory settings, enable researchers to thoroughly and systematically assess the variables causing treatment relapse in ways unavailable to applied researchers and practitioners (Kelley et al., 2015). However, the generality of effects observed with nonhumans to socially significant human behavior should not be taken for granted. Translational research that incorporates some of the advantages of experimental control that characterize these basic procedures, while using human participants, can help bridge the gap between the basic and applied literature (Lerman, 2003). Translational research involves two-way collaboration between basic and applied researchers. This can involve posing basic research questions with specific implications for application with humans, evaluating these questions with nonhumans, and then replicating those investigations with human subjects with highly controlled conditions, responses, and reinforcers (Kelley et al., 2015). The present study builds upon existing basic and translational research as an example of the latter step.

Translational research methodologies can be useful tools in investigating the variables that contribute to treatment relapse, including resurgence.

As demonstrated by both basic and applied investigations of the variables influencing resurgence of extinguished behavior, changes in the contingencies of reinforcement for functional alternatives to problem behavior can bring about substantial treatment relapse (Volkert et al., 2009; Winterbauer & Bouton, 2010).
Investigations of resurgence model the ways in which errors of omission may contribute to failed maintenance of behavior change. Nevertheless, treatment relapse under natural conditions is a complex phenomenon. Therefore, resurgence is not the only model of treatment relapse with applied significance.

**Renewal**

In addition to resurgence associated with errors of omission, another behavioral process that is often relevant in cases of treatment relapse is the stimulus context: changes in environmental conditions that control behavior. Laboratory models used in basic research also have demonstrated that changes in the stimulus context following treatment can produce a relapse of extinguished behavior, termed renewal (e.g., Bouton, Todd, Vurbic, & Winterbauer, 2011; Kelley et al., 2015). The most common form of renewal occurs when returning to the context in which the response was previously reinforced results in reemergence of behavior that was extinguished in a different context (Kelley et al., 2015).

Like resurgence, renewal can be characterized by a sequence of three phases. In ABA renewal, the target behavior is reinforced in Context A. For example, Bouton et al. (2011) conducted experiments to examine relapse of lever pressing in rats. Lever pressing was reinforced in Context A. When the rats were moved to context B, lever pressing was placed under extinction, in that food pellets were no longer provided for responding on the lever. As a result of the extinction procedure, the rate of lever pressing fell to near-zero levels for all subjects. Finally, the rats were returned to Context A. Although the extinction procedure was
continued in this context, the rate of lever pressing increased. This demonstrates behavioral relapse in the form of renewal. ABA renewal can be understood as a progression across three phases. For example, a child’s problem behavior (e.g. aggression) may have a history of reinforcement (e.g., escape from demands) within the home (Context A). This is analogous to Phase 1 in basic studies. The aggression may be treated with DRA in a clinical setting (Context B), as in Phase 2. In this example, escape from demands might be provided only for an alternative behavior, such as requesting a break, but not provided following aggression. However, aggressive behavior may relapse when the child is returned to the home setting (Context A), despite the fact that the parents continue implementing the DRA procedure with high fidelity (i.e., the problem behavior is not being reinforced). This final test for renewal is analogous to Phase 3 of renewal studies.

In addition to ABA renewal, relapse could occur when all three stimulus contexts are different (ABC renewal). In ABC renewal, initial reinforcement takes place in one context (A), extinction of the targeted behavior takes place in a second context (B), and then extinction is continued in a third context (C; Bouton et al., 2011). In both cases, extinguished responding reemerges in the third stimulus context (see Bouton et al., 2012, for a review). Basic research findings indicate that removal from the stimulus context in which targeted responding is extinguished is often sufficient to cause renewal of extinguished target responding, regardless of whether the context change consists of restoration of stimulus conditions present during reinforcement of the behavior (Bouton et al, 2011). In applied settings,
renewal may help to explain why problem behavior that occurs in a client’s home or school context after successful treatment in the clinical setting. Problem behavior could reemerge when the client returns to those contexts (ABA renewal) or transitions to a new context, such as a new school (ABC renewal).

**Combinations of Resurgence and Renewal**

Evaluations of resurgence and renewal are typically conducted separately, but it is advantageous to consider their combination, as variables that contribute to both relapse phenomena could be in effect at the same time (Sweeney & Shahan, 2015). When considering examples of DRA treatment relapse in clinical applications, it is important to recognize that rarely are contingency changes, including treatment-integrity errors, entirely separate from changes in context. Behavioral relapse may be observed in the original reinforcement context when attempting to extend DRA treatment from a clinical setting to the home or school context – renewal. At the same time, caregivers might fail to consistently reinforce alternative behavior – resurgence. Relapse in such a case would involve the effects of both renewal and resurgence.

Evaluations of resurgence incorporating changes in context have been conducted with both human and nonhuman participants, (Bouton & Trask, 2016; Kincaid, Lattal, & Spence, 2015; King & Hayes, 2016; Podlesnik & Kelley, 2014; Shahan & Sweeney, 2016). Bouton and Trask (2016) examined how changes in both physical context and reinforcer presentation affected lever pressing in rats. In Phase 1 within Context A, rats were trained to lever press for a specific reinforcer.
Then, in Phase 2 within Context B, this response was placed on extinction while a separate, alternative reinforcer was provided non-contingently (independent of responding). Finally, four different tests for relapse were conducted in Phase 3. In Test 1, alternative reinforcers were presented within Context B, and no relapse was observed. In Test 2, these alternative reinforcers were presented while in training Context A, and moderate relapse was observed. In Test 3, alternative reinforcement was removed in extinction Context B, and moderate relapse was observed. In Test 4, alternative reinforcement was removed in training Context A, and even greater relapse was observed. Relapse was therefore lower in conditions in which the physical context or reinforcer that had been paired with extinction (B) was present, and was greatest in conditions in which removal of alternative non-contingent reinforcement was combined with a return to the training Context A.

Thus, resurgence and renewal both had separate but additive effects on relapse in the experiment. These findings, establishing increased relapse when resurgence and renewal are combined, have been demonstrated with pigeons (Kincaid, Lattal, & Spence, 2015; Podlesnik & Kelley, 2014) and laboratory procedures with university students (King & Hayes, 2016). Altogether, multiple evaluations of the combined effects of resurgence and renewal with both humans and nonhumans provide evidence that resurgence effects may be greater when variables contributing to renewal are simultaneously manipulated (but see Sweeney & Shahan, 2015).
The evaluations of combined renewal and resurgence on relapse conducted in the basic and translational literature involve superimposing context changes on tests for resurgence (Bouton & Trask, 2010; Kincaid et al., 2015; King & Hayes, 2016; Shahan & Sweeney, 2016). A typical evaluation of combined renewal and resurgence consists of comparing Phase 1 target reinforcement in Context A, Phase 2 differential reinforcement in Context B, and Phase 3 extinction in Context A, to a resurgence procedure in which all phases are conducted in Context A. Phase 3 in these kinds of experimental comparisons therefore consists of extinction for both alternative and target responding. As a result, the procedures are analogous to a clinical situation in which problem behavior is originally reinforced at home, treated with DRA in the clinic, and then both the alternative response and problem behavior are placed on extinction at home. This may at times be the case if a parent were not informed or trained in implementing the DRA treatment. However, it is likely that most practitioners will train parents to implement DRA at home to some degree. Thus, the return to the home context will not usually be characterized by complete abandonment of the DRA reinforcement contingency (i.e., extinction of alternative responding). In most natural situations, the existing experimental model does not adequately reflect the applied problem.

The Present Study

In applied examples of renewal of problem behavior, DRA will often be implemented both in the clinic (Context B) and after returning to the home (Context A). However, parents might not implement the DRA treatment with full
integrity. For example, problem behavior may be placed on extinction, but the parents may fail to reinforce alternative responses consistently (errors of omission). In such cases, it is worthwhile to determine to what extent the relapse of problem behavior is due to the return to the reinforcement context (A), or to the extinction of alternative responding due to errors of omission. The combined effects of renewal and resurgence can be investigated in a manner more closely resembling applied examples of DRA treatment relapse by manipulating levels of treatment integrity within a test of renewal. In doing so, this study expands on the existing literature investigating combinations of renewal and resurgence. Specifically, the present study compared relapse of behavior reduced through DRA in two procedures (See Table 1). In the 100% condition, reinforcement of target behavior occurred in Phase 1 within Context A, DRA occurred in Phase 2 within Context B, and DRA was continued in Phase 3 within Context A. In the 0% condition, reinforcement of target behavior occurred in Phase 1 within Context A, DRA occurred in Phase 2 within Context B, and extinction of both target and alternative behavior occurred in Phase 3 within Context A.

The goal of this investigation was to evaluate the generality of combined renewal and resurgence effects upon extinguished alternative behavior in children diagnosed with ASD. This is a clinically relevant population, as DRA is one of the most common behavioral procedures used with young people diagnosed with ASD. Specifically, the investigation compared the effects of DRA implemented with either 100% or 0% of alternative responses reinforced when the participant returned
to the reinforcement context (A) on the relapse of target behavior. The latter procedure represents a combination of renewal and resurgence, previously shown to enhance relapse compared to assessing either process on its own (e.g., Bouton & Trask, 2016; Kincaid et al., 2015). While DRA implemented with 100% of alternative responses reinforced, as in the 100% condition, may be difficult for parents to maintain in the natural environment, it is representative of the contingencies most likely to be in place when DRA is first implemented. Over time, the schedule of reinforcement may be thinned so that not every alternative response immediately contacts reinforcement.

This evaluation was translational in that it used arbitrary responses and highly controlled conditions to allow for greater experimental control over relevant variables. Some of the limitations of studying actual problem behavior and alternative behavior in clinical settings include variability in response effort and length of reinforcement history between the target and alternative responses, as well as the potential for problem behavior to pose risks to the individual or others. The identical arbitrary responses prevented a difference in response effort or past exposure to reinforcement from confounding the experiment’s comparison of relapse tests. Moreover, use of arbitrary responses allowed the study to demonstrate the effects of renewal and resurgence without some of the ethical and safety concerns of targeting actual problem behavior. By using a translational model to evaluate the combined effects of stimulus context and treatment integrity failures on renewal of extinguished responding, this investigation provides
information on the extent to which both contingencies and context impact maintenance and generalization of behavior change. The results of this study may contribute to an empirical basis for improving DRA and developing new behavioral treatments.

**Method**

**Participants**

Three children participated in this study. Note that names have been changed. Isaac was an eight-year-old diagnosed with ASD. He communicated verbally using complex sentences, and attended a classroom with typically developing peers. He did not receive intensive behavior analytic treatment before or during the study, but attended a social skills group for children with ASD once a week. Yolan was a six-year-old diagnosed with autism. He did not communicate using words, signs, or any other communication system, and was not receiving ABA therapy. Nathan was a three-year-old diagnosed with autism. He received 30 hours a week of intensive ABA therapy and communicated using modified sign language.

**Setting and Materials**

We conducted sessions in small rooms or partitioned sections of rooms at The Scott Center for Autism Treatment. Each room was equipped with a table and chairs, edibles, and session materials. All sessions were videotaped. In those phases that took place in Context A, contextual stimuli including the experimenter’s shirt, table covering, and data collection materials were colored
either red or blue. The colors associated with each phase were counterbalanced across participants, so some participants experienced Phase 1 with red contextual stimuli, and others with blue contextual stimuli. In those phases taking place in Context B, contextual stimuli were the other color. For example, if the Context A color were red for a participant, the context B color would be blue. The rooms used for each phase were kept constant for each participant, as was the arrangement of all furniture and other stimuli in the room.

Two Montessori Object Permanence Boxes were used to evaluate target and alternative responses. These boxes are 10 cm x 15 cm x 15 cm wooden containers attached to a 15 cm x 15 cm wooden tray. At the top of the box is a hole into which the participant may drop a small plastic golf ball, and the ball will roll out through an opening in the side of the box, and onto the tray. This allows the participant to repeatedly place the ball in the hole and retrieve it. One natural wood box was used to evaluate the target response, and a second box, painted green, was used to evaluate the alternative response.

**Response Definition and Measurement**

The primary dependent variables were the rate of the target response and alternative response in each session in responses per min. The target response was defined as dropping the ball into the natural wood box, and the alternative response as dropping the ball into the green box. In phases in which both boxes were available, they were placed symmetrically in front of the participant, with the target box to the participant’s left, the alternative box to the participant’s right, and a
single ball placed in between the two boxes at the start of the session. This allowed the response effort for both target and alternative responding to be equivalent.

Additional dependent variables that were measured included frequency of emotional responses such as crying, whining, or other vocalizations above conversational level, with an immediate onset and 3-s offset. The frequency of “other” responses was also measured. These included any other responses maintained by access to the edible reinforcers, such as verbal requests for edibles or attempts to steal edibles. We also collected data on out-of-seat duration, defined as when the participant’s bottom was not in contact with the chair with immediate onset and offset, and on reinforcer deliveries, defined as each instance of placing an edible in front of the participant.

**Experimental Design**

We conducted two conditions testing for relapse of target behavior for each participant: a 100% Condition and a 0% Condition. The two conditions modeled different levels of treatment integrity with which DRA was implemented in Phase 3; either 100% or 0% of alternative responses were reinforced in the respective conditions. Both conditions included three phases, as shown in Table 1. The experiment used a reversal design, in that participants were exposed to Phase 1, Phase 2, and one of the two relapse-test conditions in Phase 3, and then were again exposed to Phase 1, Phase 2, and then the other relapse test in Phase 3. The order was counterbalanced across participants in that some participants experienced the 100% condition in the initial Phase 3 sessions, and the others experienced the 0%
condition in the initial Phase 3 sessions. This counterbalancing was implemented in order to account for the possibility of order effects.

**Procedure**

All participants attended experimental sessions two to five times per week. During each visit, we conducted four to ten sessions, depending on availability. Counterbalancing of the box arrangements across sessions was not implemented because the first participant, Isaac, had a side bias, meaning that in initial sessions he attended to the box on his left side, regardless of the contingency in place.

**Preference Assessment.** At the beginning of every session and in all phases, the experimenter conducted a multiple-stimulus-without-replacement (MSWO) preference assessment (Carr, Nicolson, and Higbee, 2000). The two most highly preferred edibles determined by the MSWO were delivered with random alternation, according to the reinforcement schedule specified for each phase. Evidence suggests that varying highly preferred reinforcers may be more efficient in acquisition of new skills than constant delivery of the highest-preferred item (Egel, 1981). Edibles were selected that required negligible consumption time so as not to interfere with responding. As a result, consumption time was not subtracted from the total time.

**Pre-session training.** Prior to the initial session, the participant was prompted to put the ball in the box using verbal prompt (“Do this”) and model or physical prompt as needed. Edibles were delivered for every target response until the participant performed the target response ten consecutive times independently.
**Session Duration.** Session duration was determined based on each participant’s repertoire of pre-attending skills, including staying seated and facing the table, as well as on the age of participant. For Isaac, all experimental sessions were five min. Five-min sessions were probed with Nathan and Yolan. For both, out-of-seat behavior and emotional responses were high in the five-min probes, despite availability of reinforcement for responding. Session length was decreased to 2 min for these participants, which increased the likelihood each participant stayed seated during the duration of each session.

**Phase 1 – Target Reinforcement in Context A.** In this phase, sessions were conducted in Context A, as described above. The target (natural wood) box was placed to the left of the participant and the participant was given the instruction “You can put the ball in the box. You can do as much or as little as you want. Start.” One of the two highly preferred edibles were then delivered for every independent response on a variable-ratio (VR2) schedule. In other words, the number of responses required for delivery of an edible varied, but on average every second consecutive target response resulted in edible delivery. Use of intermittent reinforcement on a VR schedule increases resistance to extinction by making it more difficult to discriminate between conditions of reinforcement and extinction (Nevin, 2012). The reinforcement schedule selected for this phase was therefore designed to increase the probability of resurgence during Phase 3 in the 0 % condition.
Phase 2 – Differential Reinforcement in Context B. In this phase, 2- or 5-min sessions were conducted in Context B, as described above. Both the target and alternative boxes were available in this phase. The natural wood object permanence box was placed on the participant’s left and the green object permanence box on the right. When this study was proposed, it was intended that these orientations should be alternated at least every other session to account for any side bias that the participant might have. Thus, with the first participant, Isaac, the experiment was initiated with this protocol in effect. Due to a left-side bias in this participant, Phase 1 responding under extinction (0% condition) was highly erratic, as Isaac began allocating all responding to the box on his left, regardless of whether it was a target or alternative box. We returned to Phase 1 and abandoned the box alternation protocol with him and subsequent participants. Thus, the target box was always on the participant’s left and the alternative box on the participant’s right. Both boxes were equidistant from the participant, with one golf ball placed between the two boxes. The same instruction was delivered as in Phase 1: “You can put the ball in the box, you can do as much or as little as you want. Start.” However, in Phase 2, the target response (placing the ball in the natural wood box) was placed on extinction, so no target responses were reinforced. Alternative responses (placing the ball in the green box) were reinforced on a fixed ratio (FR) 1 schedule, meaning that every alternative response was reinforced.

Phase 3 - 0% or 100% alternative reinforcement in Context A. In Phase 3, differential reinforcement with either 0% or 100% reinforcement of alternative
responses was implemented in Context A. 100% sessions were conducted as in Phase 2, except for the fact that they took place in Context A rather than Context B. DRA was carried out as designed, with alternative responses reinforced on an FR1 schedule, and no target responses reinforced. In 0% sessions, no alternative responses were reinforced. As a result, the participant was exposed to extinction of both target and alternative responding.

**Interobserver Agreement and Treatment Integrity.** A second independent observer collected data on all dependent variables: target, alternative, emotional, and other responses, either simultaneously with the primary observer, or from a video recording. Agreement scores for each session consisted of dividing the total number of intervals in which both observers recorded the same count by the total number of 10-s intervals, and obtaining a percentage. Interobserver agreement was calculated for a minimum of 33% of sessions for all participants. For Isaac, mean agreement for target responses was 93% (range, 66.67 – 100%); alternative responses was 90% (range, 66.7 – 100%); emotional responses was 100%; and other responses was 99% (range, 96.67-100%). For Nathan, mean agreement for target responses was 100%; alternative responses was 94% (range, 83.33-100%); emotional responses was 99% (range 91.67-100%); and for other responses was 97.4% (range 66.7-100%). For Yolan, mean agreement for target response was 93% (range, 66.7-100%), for alternative response was 93% (range, 71-100%); emotional responses was 99% (range 91.67-100%); and for other responses was 99% (range 91.67-100%).
These secondary observers also collected data on procedural integrity for each trial, for at least 33% of sessions for all participants. Each trial was scored as an instance of procedural integrity if 1) the instruction, and 2) the reinforcement schedule for target and alternative responses were both implemented as designed for the given phase. Procedural integrity for each session was calculated by dividing the total number of trials implemented with integrity by the total number of trials in a session and obtaining a percentage. Mean procedural integrity was 100% for all participants.

**Results**

Table 2 shows the mean reinforcer rates for all conditions. For all participants, the mean rate of reinforcer deliveries was lower in Phase 1 than in Phase 2. This suggests that reinforcement rates were arranged as designed, in that the VR2 schedule in Phase 1 resulted in less frequent reinforcement than the FR1 schedule of alternative reinforcement arranged in Phase 2. Figure 2 shows rates of target and alternative responses across sessions. We saw a similar pattern in all three participants in Phases 1 and 2. In Phase 1, target responding increased gradually and then stabilized under the VR2 schedule of reinforcement. For Yolan, however, Phase 1 responding was more variable than for Isaac and Nathan, so stabilization criteria were considered met when session data was close to the average of the last few sessions. The level of target responding was relatively equal for the first and second Phase 1 for all three participants, and Yolan’s target responding was less variable in the second Phase 1 compared to the first.
In Phase 2, alternative responding exceeded target responding when alternative responding was reinforced on an FR1 schedule for all participants. Rates of alternative responding in Phase 2 were lower than rates of target responding in Phase 1, likely due to the increased consumption time under the FR1 schedule of reinforcement. Compared to the VR2 schedule, the FR1 schedule resulted in a greater quantity of edible reinforcers (see Table 2), and consumption of edibles may have competed with responding. For Yolan, there was a gradual reduction in target responding and corresponding increase in alternative responding. For both Isaac and Nathan, target responding immediately fell to zero or near zero levels when the alternative response was introduced and reinforced. Yolan’s rate of alternative responding initially decreased across the first Phase-2 session, but then stabilized. Nathan’s alternative responding stayed relatively stable across Phase 2. For Isaac and Nathan, the level of Phase 2 responding was roughly equivalent in the first and second Phase-2 conditions. Yolan’s level of alternative responding was lower in the second Phase 3 than in the first. For all three participants, target responding dropped to zero or near-zero levels when the second Phase 2 was initiated.

In Phase 3, for all participants, target responding initially remained at near-zero levels in the 100% condition. In this condition, alternative responding was maintained with FR1 reinforcement, and target responding remained on extinction, but there was a transition back to Context A. For Yolan and Nathan, resurgence of target responding was observed roughly halfway through the 100% condition, but
for Isaac, no resurgence of target responding was observed in this condition. For all three participants, resurgence of target responding was greater in the 0% condition than in the 100% condition. For Yolan and Nathan, target responding resurfaced early in Phase 3 during the 0% condition, and gradually decreased to near-zero levels. Isaac’s pattern of responding was different. We observed a rapid reduction in alternative responding and a rapid increase in target responding that eventually stabilized at the level of Phase 1 target responding. Thus, for Isaac, when exposed to extinction for both target and alternative responses, responding was quickly allocated to the target response that had been reinforced in Context A during Phase 1. Target responding did not extinguish in the 0% condition for Isaac despite the absence of reinforcement.

Figure 3 summarizes the data in Figure 2 by showing mean rates of target and alternative responding within each phase. Figure 3 shows a common pattern among participants: in Phase 2 alternative responding occurred to a greater proportion than target responding. In Phase 3 100%, target responding remained low and alternative responding remained high. In Phase 3 during the 0% condition, however, target responding increased, thereby demonstrating resurgence.

Figure 4 shows the target response rate as a proportion of Phase 1 for all three participants. Greater resurgence was observed in the 0% condition for all participants. Moreover, the pattern of resurgence across sessions was similar for Yolan and Nathan in that target responding resurfaced higher and earlier in the 0% condition than the 100% condition. For Isaac, there was a pattern of increased
allocation to the target response across sessions. After three sessions in the 0% condition, Isaac’s target responding overtook alternative responding. This continued until target responding reached Phase-1 levels and alternative responding was extinguished. Target responding did not extinguish despite the absence of reinforcement.

In Phase 3, emotional and other responses were observed. Table 3 shows the total number of emotional and other responses in both Phase 3 Conditions. For all three participants, emotional and other responses were higher in the 0% condition than in the 100% condition. For Isaac, emotional responses consisted of crying and whining, and other responses consisted of requests and demands for snacks. For Yolan, emotional responses consisted of crying and loud vocalizations, and other responses consisted of attempts to steal edibles. Anecdotally, we also observed a higher frequency of hand-mouthing, a behavior seen at low rates during other phases and between sessions. Yolan had the same number of other responses between the two conditions. Nathan’s emotional responses consisted of loud vocalizations and crying, and his other responses consisted of reaching for the therapist’s hands and the sign for “eat fish,” a request for Goldfish crackers. For all three participants, the difference in emotional responding between the 100% and 0% conditions was more dramatic than the difference in target relapse between the two conditions. Duration out-of-seat was also recorded across all three phases. Table 4 shows total duration out of seat and mean percentage of session out-of-seat.
All three participants were observed to leave their seats for a greater total duration and percentage of session in the 0% condition compared to the 100% condition.

**Discussion**

Understanding the variables that contribute to treatment relapse is critical in developing problem behavior management strategies that maintain over time and generalize across settings. Information about the conditions under which problem behavior is likely to resurge after DRA can be used to inform clinicians and caregivers about methods to reduce relapse. This investigation compared the effects of DRA implemented with either 100% or 0% reinforcement of alternative responding when the participant returned to the reinforcement context (A). The 0% procedure represented a combination of renewal and resurgence, which has been shown to enhance relapse compared to each process in isolation (Bouton & Trask, 2016; Kincaid et al., 2015). The 0% condition also modeled errors of omission in implementation of DRA, in which there is failure to provide reinforcement for alternative responses. For all participants, greater resurgence of target responding was observed in the 0% condition. The 100% condition is a model of ABA renewal with DRA maintenance, whereas the 0% condition is a model of ABA renewal with 0% of alternative responses reinforced. Compared to the 100% condition, the 0% condition produced greater overall relapse of the extinguished target response. These results provide a translational representation of the sort of treatment relapse frequently seen when problem behavior of children with ASD is treated with DRA in a clinical setting (Wacker et al., 2013). In situations in which alternative
reinforcement is maintained when returning to the home context, relapse of problem behavior can be expected to be less than when alternative reinforcement is not provided in the home context.

Evaluations of resurgence that incorporate changes in context have been conducted with both human and nonhuman participants, with results indicating that the strength and pattern of resurgence due to contingency change may be partly controlled by changes in context (Kincaid & Lattal, 2016; King & Hayes, 2016; Podlesnik & Kelley, 2014; Bouton & Trask, 2016; Shahan and Sweeney, 2016). In turn, the context that comes to exert control over behavior includes not only physical features of the environment but also the contingencies that are in place in that environment. Antecedents that precede responding, and the consequences that follow, form part of the context, and therefore play a role in renewal (Bouton et al., 2012; Trask and Bouton, 2016; Podlesnik et al., in press). In natural situations, changes in both context and contingencies are likely to occur after treatment. An understanding of the combined effects of context changes and contingency changes is crucial to isolating the mechanisms of treatment relapse.

In the present study, three phases were used to evaluate the effects of context and contingency changes on treatment relapse. Phase 1 was used to establish a history of reinforcement for target responding. Phase 2 simulated DRA by providing reinforcement for an alternative response and extinction for the target response. For all participants, the results of Phase 2 indicate that simultaneously reinforcing alternative responses and extinguishing target responses results in a
decrease in the rate of target responding and increase in the rate of alternative responding (Petscher, Rey, & Bailey, 2009; Tiger, Hanley, & Bruzek, 2008). Nonetheless, the decrease in alternative responding during Phase 2 was more abrupt than what is sometimes seen in the applied literature investigating DRA treatments such as FCT. This could be due to the high discriminability of the condition change, as the transition from Phase 1 to Phase 2 involved a change in color-coordinated contextual stimuli, as well as the addition of a separate alternative Object Permanence box that was not available in Phase 1. This highly salient condition change may be responsible for the immediate zero- and near-zero rates of target responding seen in Phase 2 for Isaac and Nathan. The fact that the alternative response was unavailable until Phase 2 makes the procedures an appropriate model of DRA used to teach a new behavior not in a client’s current repertoire, rather than DRA used to reinforce an existing appropriate behavior.

Phase 3 compared conditions in which alternative reinforcement was maintained when returning to Context A (100%), and in which it was not (0%). In Phase 3, greater relapse occurred in the 0% condition for all participants. The results of the 0% and 100% relapse tests in Phase 3 for Yolan and Nathan are consistent with the previous literature investigating combinations of resurgence and renewal (Bouton & Trask, 2016; Kincaid et al., 2015; King & Hayes, 2016). Specifically, the greater initial increase in target responding during the 0% condition is in line with experimental demonstrations of more abrupt relapse when variables contributing to both resurgence and renewal are present. Thus, the test for
resurgence that models a breakdown in the DRA procedure in the form of omission errors (0% condition) resulted in more abrupt and greater resurgence than the condition that models DRA maintenance (100% condition). Both conditions incorporate an ABA context change, and it was therefore expected that some relapse would occur in the 100% condition – consistent with the renewal effects established in the basic and applied literature (e.g., Bouton et al., 2011; Durand & Carr, 1991; Luczynski, Hanley, & Rodriguez, 2014). Return to the training or reinforcement context results in increases in extinguished behavior, a finding that was observed for two of the three participants in the present study (Kelley et al., 2015; Kincaid et al., 2015). Renewal in the 100% condition was observed for Yolan and Nathan, but not for Isaac. Nonetheless, the literature on combinations of resurgence and renewal supported the expectation that resurgence effects would be more robust in the 0% condition. In the present study, this result was confirmed with all three participants.

Isaac’s data were generally in line with the expectations of the study in that greater relapse occurred in the 0% condition compared to the 100% condition. For Isaac, exposure to the 0% condition did not produce extinction of responding. Isaac’s distinct pattern of responding may be explained by a number of factors. First, Isaac might have responded in the absence of reinforcement because responding was under strong instructional control. In other words, Isaac’s history of exposure to people providing rules (e.g. teachers, therapists) might have contributed to the development of rule-governed behavior that supplanted the
contingencies arranged in the study. Second, the process of putting the ball in the object permanence box may have functioned to produce some automatic reinforcement. It is possible that the response gave him “something to do” to pass the time during exposures to extinction. Third, the salience of the contingency change may have overshadowed the effects of the context change. Isaac engaged in increased emotional and other responses during the 0% condition, and verbally expressed that the experimenter was “tricking him,” or “hiding snacks.” Isaac’s discrimination of the contingency change from DRA to extinction may have had more control over his behavior than his discrimination of the context change.

In the present study, contingency changes enhanced the effects of context changes on relapse. When the response-reinforcer relationship was disrupted in the transition to Context A, target responding reoccurred with greater frequency than when the response-reinforcer relation for alternative responding was maintained. Operant behavior is clearly sensitive to past reinforcement histories (Lieving & Lattal, 2003). The present study falls in line with studies of these behavioral history effects in that it used three phases to examine behavioral persistence as a function of preceding conditions. Similarly, Lieving and Lattal (2003) found resurgence under conditions in which there were relative reductions in reinforcer availability across phases. In four experiments with pigeons, the authors found that nonreinforcement conditions produced resurgence, whereas response-independent presentation of reinforcers at the same rate as the previous condition did not (see also Marsteller & St. Peter, 2014). These findings indicate that resurgence results
from a shift in reinforcer availability. When fewer reinforcers are delivered, there are longer periods of nonreinforcement, thereby making relapse of target behavior likely to occur (Lieving & Lattal, 2003). In the present experiment, the 0% condition exposed participants to extinction of alternative responding, inducing target responding to a greater degree than exposure to the acquisition context alone. When there was a relative shift in the rate of reinforcement as in the 0% condition (see Table 2), we observed resurgence. These results are consistent with Lieving and Lattal’s findings.

The results obtained in the present study for the 0% condition are also consistent with the findings of Kelley et al. (2015). The authors arranged two experiments in which reinforcement for a target response was followed by extinction with different or identical contexts relative to the first phase (ABA renewal). Results with pigeons and translational replications with children with autism indicated that returning to a context in which a target response had previously been reinforced produced an increase in extinguished responding. In accordance with these findings, the present study’s results indicate that both context and contingencies exert control over behavior. In the present study, target responding was reinforced in Phase 1, extinguished in Phase 2 through a DRA procedure, and resurged in Phase 3 under extinction conditions. The fact that relapse was observed in the 100% condition for two of the three participants, indicates that the effects observed in the 0% condition reflect the combined effects of renewal due to context change and resurgence due to errors of omission.
Along with these previous studies, the present study contributes to the body of research investigating the components that make DRA an effective behavioral treatment. Part of the process of developing more effective DRA treatments involves programming for generalization of behavior change across contexts. The existence of renewal effects in basic, translational, and applied studies establishes the fact that context is a crucial factor in the maintenance of treatment results (Bouton et al., 2012; Kelley et al., 2015; Durand & Carr, 1991). Understanding methods for mitigating relapse may be critical in applications ranging from treatment for problem behavior of individuals with disabilities, acquisition of skills, and treatment of addictions and other socially significant behavioral problems. Multiple-context training has been used to increase the generalization of behavior, and is consistent with the recommendation of Stokes and Baer (1977), that practitioners “train sufficient exemplars” in order to promote generalization. In the case of DRA treatment, this approach would involve arranging for Phase 2 treatment (extinction of target behavior and reinforcement of alternative behavior) across multiple settings. Studies of treatment conducted across contexts have demonstrated that exposure to multiple contexts increases generalization (Balooch & Neumann, 2011; Todd et al., 2012).

In the present study, color-coded stimuli used during reinforcement of target responding came to evoke target responses (ABA renewal). Relapse in the presence of A Context stimuli was observed both with and without maintenance of DRA contingencies. This indicates that stimuli present during reinforcement may
evoke previously reinforced behavior, whereas stimuli present during extinction may suppress previously reinforced behavior. It follows that another method of promoting generalization is to incorporate extinction cues, stimuli used during extinction, as a means of promoting maintenance of treatment effects outside the original extinction context (Brooks & Bouton, 1994; Stokes and Baer, 1977). In the present study, the context present during the initial training of target behavior evoked target responding for two participants in the 100% condition. Similarly, the context present during extinction of target responding can evoke little target responding. By carrying over contextual stimuli from the context in which DRA treatment is conducted into the generalization contexts, practitioners may increase the likelihood that the extinction of the target response and acquisition of the alternative response will maintain in different settings.

The results of this study extend findings from the current literature on resurgence and renewal by revealing the effects of ABA context change after DRA on relapse with and without errors of omission. The data that this investigation yields contribute to a better understanding of the complex processes contributing to relapse of problem behavior after DRA treatment. A better understanding of the processes contributing to treatment relapse will aid practitioners in programming for the maintenance of behavior change (see Mace & Critchfield, 2010; Pritchard et al., 2014). Techniques to mitigate the effects of environmental change after treatment and errors of treatment integrity require further development. Methods used in the present study provide a platform from which to obtain better
understanding of how these variables contribute to relapse individually and in combination. Thus, these findings may contribute to developing more effective DRA interventions.
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Table 1

*Three Phases of Two Conditions*

<table>
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<tr>
<th></th>
<th>100% Condition</th>
<th>0% Condition</th>
</tr>
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<tbody>
<tr>
<td>Phase 1: Target-response Reinforcement in Context A</td>
<td>• Target response reinforced</td>
<td>• Target response reinforced</td>
</tr>
<tr>
<td></td>
<td>• Alternative response absent</td>
<td>• Alternative response absent</td>
</tr>
<tr>
<td>Phase 2: Alternative Reinforcement in Context B</td>
<td>• Target response extinguished</td>
<td>• Target response extinguished</td>
</tr>
<tr>
<td></td>
<td>• Alternative response reinforced</td>
<td>• Alternative Response extinguished</td>
</tr>
<tr>
<td>Phase 3: 100% Alternative Reinforcement in Context A</td>
<td>• Target response extinguished</td>
<td>• Target response extinguished</td>
</tr>
<tr>
<td></td>
<td>• Alternative response reinforced</td>
<td>• Alternative Response extinguished</td>
</tr>
<tr>
<td>Phase 3: 0% Alternative Reinforcement in Context A</td>
<td>• Target response extinguished</td>
<td>• Target response extinguished</td>
</tr>
<tr>
<td></td>
<td>• Alternative Response extinguished</td>
<td>• Alternative Response extinguished</td>
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Table 2

*Mean Rate Reinforcer Deliveries in the two Conditions*

<table>
<thead>
<tr>
<th>Participant</th>
<th>100% Condition</th>
<th>0% Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Rate Reinforcer Deliveries</td>
<td>Mean Rate Reinforcer Deliveries</td>
</tr>
<tr>
<td></td>
<td>Phase 1</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Isaac</td>
<td>10.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Yolan</td>
<td>8.5</td>
<td>11.6</td>
</tr>
<tr>
<td>Nathan</td>
<td>4.1</td>
<td>6.1</td>
</tr>
</tbody>
</table>

*Note.* Mean reinforcer deliveries per minute for each of three phases in the 100% and 0% condition for three participants.
Table 3

*Emotional and Other Responses in the two Phase 3 Conditions*

<table>
<thead>
<tr>
<th>Participant</th>
<th>100% Condition</th>
<th>0% Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of</td>
<td>Emotional</td>
</tr>
<tr>
<td></td>
<td>sessions</td>
<td>responses</td>
</tr>
<tr>
<td>Isaac</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Yolan</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Nathan</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note.* Total numbers of sessions, total numbers of emotional and other responses in Phase 3 in both 100% and 0% conditions for three participants.
Table 4

*Total Duration and Percent of Session Out of Seat in the two Phase 3 Conditions*

| Participant | 100% Condition | | | 0% Condition | | |
|-------------|-----------------|-------|-----------------|---------------|-------|
|             | Number of sessions | Total Duration | Mean % of Session Out of Seat | | Number of sessions | Total Duration | Mean % of Session Out of Seat |
| Isaac       | 9               | 36.4   | 0.0%            | | 8               | 228.4 sec  | 0.1%            |
| Yolan       | 10              | 353.0  | 0.3%            | | 11              | 485.2      | 0.4%            |
| Nathan      | 10              | 0      | 0%              | | 8               | 159.6      | 0.2%            |

*Note.* Total number of sessions, total duration out of seat, and mean percent of session out of seat in 100% and 0% conditions for three participants.
Figure 1. Montessori Object Permanence Box used to model target and alternative responses
Figure 2. Target (closed circles), and alternative (open squares) responses per min. Note that the y-axes differ across participants.
Figure 3. Bars represent average rates of target response and alternative response per phase (including Phase 1, Phase 2 and Phase 3 in both 100% and 0% Conditions. Note that the y-axes differ across participants. Gray and White segments are stacked. White segments are average rates of alternative response, and gray segments are average rates of target response. The order of conditions for Isaac and is depicted in the opposite to the order conducted during the study to better illustrate the common pattern among participants.
Figure 4. Target-response rate as a proportion of Phase 1 in both conditions. The y-axis is the rate of response that is proportionate to Phase 1 level of target response. The x-axis is sessions. The closed circles represent the target response in the 100% Condition, and the x symbols represent the target response in 0% Condition. The first data point in each graph is the last session of Phase 2, and the rest of the data points are sessions in Phase 3 of the two conditions.