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Refining Noncontingent Reinforcement Treatments Using Behavioral Momentum Theory

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REFINING NONCONTINGENT REINFORCEMENT TREATMENTS USING BEHAVIORAL MOMENTUM THOERY

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One of the most effective and commonly prescribed treatments for children with autism and/or an intellectual disability who engage in severe destructive behavior is called noncontingent reinforcement (NCR). During NCR, the consequence that previously reinforced destructive behavior is delivered on a time-based schedule, independent of destructive behavior, and the contingency between destructive behavior and its reinforcer is discontinued (operant extinction; EXT). Conceptual and quantitative derivations of behavioral momentum theory (BMT) suggest that certain aspects of NCR may inadvertently promote persistence of destructive behavior, thereby prolonging the treatment process. Guided by Shahan and Sweeney's (2011) model of resurgence based on BMT, this dissertation evaluated two refinements to NCR designed to reduce behavioral persistence during treatment and mitigate response resurgence following NCR when all reinforcement was withdrawn. In Experiment 1, we evaluated a procedure designed to increase the saliency of the change from contingent reinforcement to NCR by altering a reinforcer parameter related to contingency discriminability, which BMT predicts will lead to faster reductions in target responding and decrease the likelihood of resurgence. Behavioral momentum theory also predicts that implementing NCR without EXT (as is commonly done for destructive behavior maintained by sensory reinforcers) increases the likelihood of resurgence. Therefore, in Experiment 2, we compared levels of resurgence when NCR was implemented with and without EXT. Results suggest that the proposed refinements are effective, to varying degrees, at reducing behavioral persistence during NCR and mitigating response resurgence. Findings are discussed within a translational research framework and broader context of strategies used to mitigate treatment relapse for severe destructive behavior.

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LIST OF ABBREVIATIONS

BMT	behavioral momentum theory
DRA	differential reinforcement of alternative behavior
DRO	differential reinforcement of other behavior
EO	establishing operation
EXT	extinction
FCR	functional communication response
FCT	functional communication training
FI	fixed interval
FR	fixed ratio
FT	fixed time
NCR	noncontingent reinforcement
PR	progressive ratio
RDC	response-dependent component
RIC	response-independent component
RPH	responses per hour
SIB	self-injurious behavior
VI	variable interval
VR	variable ratio
VT	variable time

INTRODUCTION

Human Behavior

Much of human behavior is shaped by its consequences. A consequence is a stimulus or event that follows a behavior, and the relation between behavior and its consequences is often expressed in terms of responses and reinforcers. The process by which reinforcers come to shape, or operate upon responses is known as operant conditioning (Skinner, 1953). Providing reinforcement contingent upon a behavior increases the probability that the response will occur again. However, responses are not reinforced in a vacuum, and contextual influences also play a part of operant conditioning. In this vein, Skinner proposed the three-term contingency, which states that, the presence of a contextual variable (referred to as a discriminative stimulus) that is associated with reinforcement for a specific response will increase the probability of that response. Discriminative stimuli may also be associated with consequences that decrease the probability of a response such as the absence or termination of reinforcement (i.e., operant extinction; EXT) or the presence of punishment.

It is through operant conditioning that humans learn how to interact with their surrounding environment. This includes a wide spectrum of learned behaviors including simple responses such as kicking a ball to more sophisticated behavior such as decision-making and thinking. Operant conditioning, and the principles of behavior more broadly, have been employed to understand and solve complex problems of the human condition including mental health disorders (Dimidjian, Barrera, Martell, Muñoz, & Lewinsohn, 2011), substance abuse (Higgins, Silverman, & Heil, 2008), and the assessment and treatment of severe behavior disorders (Iwata et al., 1994).

Severe Destructive Behavior in Autism and Intellectual Disabilities

Approximately four million people in the United States have an intellectual disability, and 12.5% (one-half million) engage in severe destructive behavior, such as self-injury, aggression, and property destruction (Emerson et al., 2001). Studies that have assessed the prevalence of challenging behaviors, including severe destructive behavior in individuals with autism spectrum disorder have found that these behaviors can occur at rates as high as 96% in this population (Jang, Dixon, Tarbox, & Granpeesheh, 2011; Kozlowski, Matson, & Rieske, 2012).

The risk for engaging in destructive behavior increases with intellectual-disability severity, communication deficits, and co-occurring autism spectrum disorder (Holden & Gitlesen, 2006). There are serious health risks associated with engaging in self-injurious behavior (SIB), such as irreversible tissue damage, body trauma, physical impairment, or blindness (Hyman, Fisher, Mercugliano, & Cataldo, 1990). When individuals with an intellectual disability engage in aggression or property destruction, it may lead to injuries sustained by others in the individual's environment including caregivers, teachers, and paraprofessionals. Such injuries may warrant hospitalization or other medical attention.

Historically, treatment associated with destructive behavior has been highly intrusive, and individuals who engage in these behaviors are at increased risk for dependency on physical restraints, over-use of pharmaceutical drugs, rejection of educational services, and they have a higher likelihood of being institutionalized (Antonacci, Manuel, & Davis, 2008). Given that destructive behavior can significantly disrupt the life of individuals with an intellectual disability, as well as those caring for the individual, a large body of research in applied behavior analysis has been dedicated to the assessment and treatment of severe behavior disorders. In contrast to historical treatment methods, effective behavioral interventions take into account an understanding of the operant contingencies that affect human behavior and therefore affect the development and maintenance of severe destructive behavior.

Operant Origins of Severe Destructive Behavior

Since the publication of Carr's (1977) theoretical account of the origins of SIB, behavior analysts have become increasingly concerned with determining the function (i.e. contingencies of reinforcement responsible for) destructive behavior. The function refers to the environmental variables that precede and evoke destructive behavior and the environmental variables that follow and reinforce the behavior. For example, a child might learn that throwing toys during times when an adult is busy attending to other things (e.g., cooking) might results in the provision of adult attention. The function of disruptive behavior for such a child would be access to adult attention at times when attention would otherwise be unavailable. Results of experimental research suggest that much of destructive behavior, such as SIB, is learned behavior acquired through an individual's history of interaction with the social or physical environment (Iwata et al., 1994).

Behavior analysts identify the environmental variables responsible for the maintenance of destructive behavior across individuals using functional analysis methodology (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). A functional analysis is an assessment tool used to identify the function(s) of behavior by systematically manipulating environmental events and providing pre-determined consequences contingent on the target, problematic response. Each test condition differs with respect to the antecedents that are present and consequences delivered. Levels of problem behavior in the test condition are compared to the levels of behavior in a condition that lacks the relevant antecedent and consequent events being tested, known as the control condition. Typical test conditions in a functional analysis include testing for behavior maintained by social positive reinforcement, social negative reinforcement, and for behaviors that persist in the absence of social consequences (and thereby likely maintained by automatic reinforcement contingencies, or sensory consequences).

When testing for behavior maintained by social positive reinforcement in the form of social attention, the therapist withholds attention from the client except for the occurrence of the target behavior. When the target behavior occurs (and only when the target behavior occurs), the therapist immediately provides the client with attention. Attention is often delivered in the form of a social reprimand (e.g., “Don’t do that!”) or a statement of concern (e.g., “You might hurt yourself”). When testing for behavior maintained by social negative reinforcement in the form of escape from academic demands, the therapist continually instructs the client to complete tasks independent of all behavior except for the target destructive behavior. When the target behavior occurs, the therapist immediately removes task demands for a specified period of time. The alone condition tests for behavior that persists in the absence of social consequences. In this condition, the individual is left alone in a room with no access to toys or other materials. There are no programmed consequences for the occurrence of the target behavior. The alone condition is typically modified into an ignore condition when the target response is aggression. The ignore condition is identical to the alone condition except that a therapist is present. However, similar to the alone condition, there are no differential consequences provided contingent on the target behavior in the ignore condition. During the control condition, the therapist delivers attention at least once every 30 s and does not present any instructions. Highly preferred toys and activities are freely available, and all instances of the target behavior are ignored. If levels of the target behavior are appreciably and consistently higher in a given test condition as compared to the control condition, this indicates that behavior is maintained, at least in part, by the consequent events in that test condition.

Functional analysis has become the predominant method of prescribing effective behavioral treatments for persons with intellectual disability who display severe destructive behavior (Beavers, Iwata, & Lerman, 2013; Betz & Fisher, 2011; Hanley, Iwata, & McCord, 2003). Several studies directly comparing function-based and non-function-based treatments have consistently produced results favoring the function-based treatment approach (Emerson et al., 2001). In addition, results of meta-analyses and epidemiological studies indicate that behavioral treatments based on functional analyses outcome were more effective than those not based on a functional analysis (Holden & Gitlesen, 2006; Hyman et al., 1990; Iwata et al., 1994; Thompson & Gray, 1994). Finally, the use of function-based interventions has reduced the need for punishment procedures as well as powerful, arbitrary reinforcers that are superimposed on the existing contingencies that maintain destructive behavior (an approach historically referred to as behavior modification).

Noncontingent Reinforcement as Treatment for Severe Destructive Behavior

Iwata, Vollmer, Zarcone, and Rodgers (1993) described three classes of function-based interventions for severe destructive behavior: manipulations of establishing operations (EOs), EXT (e.g., Iwata, Pace, Cowdery, & Miltenberger, 1994), and differential reinforcement of alternative behavior (DRA; e.g., Carr & Durand, 1985). Modifications of EOs include antecedent manipulations designed to either weaken the reinforcer for destructive behavior or strengthen that of an alternative behavior. Extinction involves withholding the reinforcer that maintains destructive behavior thereby severing the response-reinforcer relation. In DRA, the aberrant behavior's reinforcer is provided contingent upon an alternative behavior and withheld for occurrences of the aberrant behavior itself (e.g., functional communication training [FCT]).

One of the most effective, commonly prescribed, and widely researched treatments for destructive behavior exhibited by individuals with intellectual disabilities has been noncontingent reinforcement (NCR; Carr et al., 2000; Carr, Severtson, & Lepper, 2009; Richman, Barnard-Brak, Grub, Bosch, & Abby, 2015). Noncontingent reinforcement is characterized as a well-established treatment for socially-maintained destructive based on the American Psychological Association Division 12 criteria for empirically supported treatments (Chambless & Hollon, 1998).

The basic premise of NCR involves providing access to a reinforcer on a response-independent basis, typically on a time-based schedule such as a fixed-time (FT) or variable-time (VT) schedule (Holden, 2005). When NCR is implemented concurrently with EXT, the effectiveness of NCR is hypothesized to result from diminishing the EO for the reinforcer maintaining destructive behavior when the schedule of NCR is dense and via EXT when the schedule of NCR is lean (Hagopian, Crockett, van Stone, DeLeon, & Bowman, 2000; Wallace, Iwata, Hanley, Thompson, & Roscoe, 2012). The effectiveness of NCR implemented without EXT for destructive behavior maintained by automatic reinforcement is hypothesized to result from reinforcer competition (Fischer, Iwata, & Mazaleski, 1997; Fisher & Mazur, 1997;

Hagopian & Toole, 2009; Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Roscoe, Iwata, & Goh, 1998; Shore et al., 1997).

There are numerous benefits of implementing NCR as a treatment for destructive behavior. For instance, NCR has been shown to produce greater, or at least comparable behavior reductions relative to other behavioral treatment such differential reinforcement of other behavior (DRO; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), DRA (Kahng, Iwata, DeLeon, & Worsdell, 1997), and EXT (Vollmer et al., 1998). Further, NCR has been shown to result in a higher rate of reinforcer delivery relative to other comparable procedures such as DRO (Britton, Carr, Kellum, Dozier, & Weil, 2000; Vollmer et al., 1993). In addition, compared to other treatments, NCR generally produces fewer side effects than EXT alone such as EXT-induced aggression and response bursting (Vollmer et al., 1993; Vollmer et al., 1998). Finally, from an experimental perspective, NCR with EXT procedures interrupt the response-reinforcer relation while still presenting the reinforcing stimulus to the individual (for destructive behavior maintained by social consequences), which allows for the examination of the response-reinforcer relation independent of stimulus-presentation effects (Thompson & Iwata, 2005).

Several studies have demonstrated the generality of NCR across behavioral function and topography. Noncontingent reinforcement has been used to effectively treat destructive behavior maintained by access to adult attention (e.g., Hagopian, Fisher, & Legacy, 1994; Mace & Lalli, 1991; Vollmer et al., 1993), access to tangible items (e.g., Lalli, Casey, & Kates, 1997; Marcus & Vollmer, 1996; Smith, Lerman, & Iwata, 1996), escape from academic instruction (e.g., Kahng et al., 1997; Vollmer, Marcus, & Ringdahl, 1995), as well as behaviors that persist in the absence of social consequences and are thereby likely maintained by automatic reinforcement contingencies (e.g., Roscoe et al., 1998; Sprague, Holland, & Thomas, 1997).

Noncontingent reinforcement has been shown to be an effective treatment for a variety of aberrant behaviors including SIB (e.g., Fischer et al., 1997) aggression (e.g., Vollmer, Ringdahl, Roane, & Marcus, 1997), disruptive behavior (e.g., Fisher, Ninness, Piazza, & Owen-

DeSchryver, 1996), inappropriate speech (e.g., Carr & Britton, 1999), pica (e.g., Piazza et al., 1998), rumination (e.g., Wilder, Draper, Williams, & Higbee, 1997), and stereotypy (e.g., Sprague et al., 1997).

Resurgence of Severe Destructive Behavior

Following successful treatment and reduction of severe destructive behavior through behavioral interventions, whether through the use of NCR or another behavioral treatment, behavior analysts must be conscientious of response resurgence. In basic experimental research, resurgence refers to the reemergence of a response during periods of disruption, such as EXT (i.e., when alternative reinforcement delivered contingently [DRA] or noncontingently [NCR] is withdrawn; Epstein & Skinner, 1980; Lieving & Lattal, 2003; Leitenberg, Rawson, & Mulick, 1975; Podelsnik & Shahan, 2009, 2010). In the assessment and treatment of severe behavior disorders, resurgence represents an important form of treatment relapse (Pritchard, Hoerger, & Mace, 2014; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009; Wacker et al., 2011, 2013). Resurgence is believed to be primarily a function of the contingency between the discriminative stimulus and the reinforcing consequence (stimulus-stimulus pairings; Nevin & Grace, 2000).

Reinforcement of a response or presentation of alternative reinforcement can be disrupted for a number of reasons such as reinforcement schedule thinning (Volkert et al., 2009; Fisher, Thompson, Hagopian, Bowman, & Krug, 2000) or failures in procedural fidelity (Fryling, Wallace, & Yassine, 2012). One of the most commonly studied sources of disruption for destructive behavior is EXT (Nevin, Mandell, & Atak, 1983; Pritchard et al. 2014; Volkert et al. 2009; Wacker et al., 2011). For example, following effective treatment of destructive behavior reinforced by escape from academic tasks using FCT, Wacker et al. introduced brief periods of EXT in which task completion and the functional communication response (FCR) no longer produced reinforcement. These brief (5 min to 15 min) periods of extinction resulted in decreased task completion, fewer FCRs, and increased rates of destructive behavior.

Preventing the resurgence of destructive behavior should be a priority in the treatment of severe destructive behavior (Nevin & Wacker, 2013). Arguably, the ultimate goal of effective behavioral treatment should be: (a) the reduction of destructive behavior to near-zero levels and (b) the prevention of response resurgence during periods of EXT or when the treatment intervention cannot be implemented (e.g., a caregiver of a child with severe aggression may be unable to deliver attention on the prescribed NCR schedule because the caregiver is attending to a sick sibling). Recent research on mitigating resurgence in clinical populations has been informed by behavioral momentum theory (BMT).

Behavioral Momentum Theory

Behavioral momentum theory is a quantitative model that is principally concerned with response persistence, and therefore is directly relevant to the reduction or elimination of destructive behavior. Response persistence can be viewed as an indication of response strength. Whereas some (e.g., Skinner, 1938) have described response strength in terms of response rate, others (e.g., Nevin, 1979) have conceptualized response strength as the continuation of a response when disrupted (e.g., reinforcer deprivation, EXT, and increased response effort). Response persistence can be determined by measuring a response's resistance to change. Nevin (1974) evaluated resistance to change using a number of different preparations and different types of disruptors. This study laid the groundwork for the current understanding of resistance to change, and what would come to be known as BMT. In applied work, the model's principal value is to serve as an integrative guide for analysis and intervention (Nevin & Shahan, 2011).

In each of Nevin's (1974) experiments with pigeons, he used a multiple-schedule arrangement wherein each component of the multiple schedule was correlated with some change in dimension of reinforcement. Continued responding in each component was then measured following the introduction of some disruptor (e.g., response-independent food delivery or EXT). Responding following disruption was compared to responding during the preceding reinforcement baseline and expressed as a proportion of that baseline. Expressing data as a proportion of baseline allows one to control for differences in response rates related to the schedule components (Mace et al., 2010; Nevin, 1988; Nevin, Tota, Torquato, & Shull 1990). Nevin's first two experiments evaluated the effects of reinforcement rate on response persistence. With two different disruptors, results demonstrated that higher rates of reinforcement during baseline (relative to lower rates) produced greater resistance to change when a disruptor was introduced. This general finding has been replicated in numerous studies, including with humans and individuals with intellectual disabilities (Dube, McIlvane, Mazzitelli, & McNamara, 2003). In Nevin's third experiment, results demonstrated that greater magnitude of reinforcement during baseline led to greater resistance to change when a disruptor was introduced. Similarly, this effect has been demonstrated across multiple species, including humans (McComas, Hartman, & Jimenez, 2008; Pinkston, Ginsburg, & Lamb, 2009; Shull & Grimes, 2006). Finally, in Nevin's fourth experiment, results demonstrated that greater resistance to change tends to occur when the delay between response and reinforcer delivery is minimized.

Since the publication of the Nevin's (1974) article, the parameters affecting resistance to change have proven to be quite robust. Interestingly, research by Nevin and others has shown that contingent delivery of reinforcers during baseline is not necessary to observe the effects of response persistence. In Experiment 1, Nevin and colleagues (1990) evaluated resistance to change by comparing a VT plus variable interval (VI) delivery of reinforcers in one component of a multiple schedule to delivery of reinforcers on a VI-only schedule in a second component. The results indicated that the component that had free delivery of reinforcers (i.e., VT + VI schedule) resulted in greater resistance to change when the investigators introduced a disruptor (EXT). Therefore, resistance to change was positively related to the overall rate of reinforcement in the component, irrespective of whether the investigators delivered reinforcers contingently or noncontingently. In reviewing several translational studies with children with intellectual disabilities, Dube, Ahearn, Lionello-DeNolf, and McIlvane (2009) concluded that increases in resistance to change of problem behavior are directly related to increases in reinforcement density in a given functional context, whether the context is defined by a treatment condition or a stimulus signaling a multiple schedule component. Research has also demonstrated this effect with alternative reinforcers (i.e., reinforcers other than the one[s] that maintain problem behavior) are used. In other words, functional reinforcers are not necessary to observe resurgence; rather, the overall rate of reinforcement in the stimulus context is a critical component affecting resistance to change (Grimes & Shull, 2001).

Given that response persistence is a function of the overall rate of reinforcement in a given stimulus context, regardless of whether those reinforcers are delivered contingently or noncontingently, researchers began investigating whether response strength resulted from respondent (or stimulus-reinforcer) contingencies rather than operant (or response-reinforcer) contingencies. In a second experiment, Nevin et al. (1990) delivered alternative reinforcers contingent on a specific, concurrently available alternative response. Again, resistance to EXT varied directly with the overall rate of reinforcement delivered in the stimulus context, regardless of whether the researchers delivered additional reinforcers contingent on the target response or on the alternative response. Thus, persistence effects are observed in the presence of the stimuli associated with schedules of reinforcement. Therefore, whereas response rate is a function of response-reinforcer relations, resistance to change is a function of stimulus-reinforcer relations (i.e., Pavlovian contingencies). In summary, the two experiments conducted by Nevin et al. demonstrated that the behavioral momentum effects resulted from stimulus-reinforcer relations (i.e., respondent), as opposed to the response-reinforcer (i.e., operant) relations. Mace et al. (1990) replicated this finding, as have a number other subsequent investigations.

The findings of early studies on response persistence and resistance to change (e.g., Nevin, 1974) collectively describe what has come to be known as behavioral momentum theory (Nevin et al., 1983). “Behavioral momentum theory” draws an analogy between the resistance to change of a response and classic Newtonian physics (Nevin & Grace, 2000). According to Newton’s second law of motion, when an external force is applied to an object in motion, the change in velocity is related directly to the magnitude of the opposing force and is related inversely to the object's inertial mass. More simply, momentum is a product of mass and velocity and can be thought of as mass in motion: the greater the mass, the more momentum an object has. With respect to behavior, when a disrupter such as EXT or satiation is applied to ongoing behavior, the decrease in response rate is related directly to the magnitude of the disrupter and is related inversely to the behavioral equivalent of mass. Whereas behavioral velocity is equivalent to ongoing response rate (Nevin et al., 1983), behavioral mass is the tendency for responding to persist when disrupted and is determined by the individual's history of reinforcement. Based on experimental laboratory research as well as research with human populations, reinforcer rate, magnitude, and delay all contribute to behavioral mass, observed as resistance to change. Thus, as behavioral mass increases, so does behavioral momentum. Momentum is a useful outcome particularly if the goal of intervention is to maintain appropriate responding (Mace & Belfiore, 1990). However, increased mass is problematic when the goal of treatment is to decrease behaviors using procedures such as NCR.

Limitations of Noncontingent Reinforcement

Despite the widespread effectiveness of NCR interventions, quantitative and empirical findings from BMT suggest that the typical manner in which NCR is implemented may promote persistence of destructive behavior, increase resistance to treatment, prolong the treatment process, and increase the likelihood of treatment relapse during periods in which NCR is not implemented with integrity (e.g., failure to deliver the reinforcer at the prescribed time).

One limitation of NCR according to BMT is that when the initial change from contingent reinforcement to NCR is not salient, destructive behavior may persist for prolonged periods. For example, if a child has historically received adult attention for engaging in SIB but caregivers subsequently implement NCR wherein attention is given freely, independent of SIB, there typically are no environmental stimuli that signal to the child that the contingency for access to attention has changed. In these cases, destructive behavior may be more persistent during NCR.

A second limitation of NCR according to BMT is that when destructive behavior is reinforced by sensory consequences, NCR is prescribed with alternative, nonfunctional reinforcers because the reinforcer that maintains destructive behavior cannot be directly accessed or withheld (Vollmer, 1994). Basic research on BMT suggests that destructive behavior may be more resistant to change when NCR is implemented without EXT (as is commonly done for behaviors maintained by sensory consequences) relative to when NCR is implemented with EXT (as is commonly done for behaviors maintained by social consequences; cf. Ahearn, Clark, Gardenier, Chung, & Dube, 2003).

These untoward effects of NCR had gone unrecognized previously. However, recent advances in BMT have produced predictions regarding the course of treatment for destructive behavior and identified ways to improve NCR.

A Model of Resurgence Based on Behavioral Momentum Theory

Nevin and Grace (2000) specified BMT predictions regarding resistance to EXT for an operant response in a quantitative model known as the augmented-EXT model:

$$\frac{B_t}{B_o} = 10^{\left(\frac{-t(c + dr)}{r^b}\right)} \tag{1}$$

In this BMT equation, EXT is characterized as a disruptor because of three primary effects that occur when reinforcement for responding is terminated. When EXT is implemented, the contingency between responses and reinforcers is suspended (represented by parameter *c*), the environment no longer includes reinforcers as stimuli (represented by parameter *d*), and time passes wherein the effects of contingency suspension and the absence of reinforcers as stimuli are assumed to increase with the passage of time (represented by parameter *t*). The parameter *d* scales the disruptive impact of the removal of baseline reinforcement in reinforcers per hour, *r*. Nevin, McLean, and Grace (2001) validated this model of extinction in a series of multiple-schedule experiments with pigeons as subjects. They evaluated parameter *c* by arranging NCR, and then showed the independent effects of parameters *c* and *d*, which combined additively during EXT. Nevin and colleagues (2001) found that when they changed multiple VI-VI schedules to multiple VT-VT schedules that presented noncontingent reinforcers at the same rates as in training, response rates decreased less with denser rates of reinforcement.

Opposing the disruptive impact of the discontinued response-reinforcer contingency and the removal of baseline reinforcement is the stimulus-reinforcer (Pavlovian) relation of the context, which is operationalized by the denominator: parameter *r* (i.e., baseline reinforcement rate) and qualified by sensitivity to reinforcement rate (parameter *b*). Thus, a high rate of reinforcement in a given context during baseline would mean a stronger stimulus-reinforcer relation between reinforcers and the context, reflected in a larger value of parameter *r* relative to a low rate of reinforcement in the context. A higher value of parameter *r* in the denominator formalizes the prediction of greater resistance to change following a high rate of reinforcement relative to a low rate of reinforcement.

Shahan and Sweeney (2011), and subsequently Nevin and Shahan (2011), developed a model of resurgence based on the augmented-EXT model that can predict the occurrence of resurgence following treatments for severe destructive behavior, including NCR:

$$\frac{B_t}{B_o} = 10^{\left(\frac{-t(c + dr + pR_a)}{(r + R_a)^{0.5}}\right)} \tag{2}$$

During resurgence, reinforcement is not only present during baseline, but is also present during EXT of the target response and reinforcement through alternative sources (e.g., NCR with EXT). The rate alternative reinforcement, parameter R_a, is scaled by parameter *p*. The model proposes that R_a has a disruptive impact on the target response when it is in place, but that it also contributes to the overall strength of the stimulus-reinforcer relation of the context. When alternative reinforcement is removed and EXT is introduced, the disruptive effects of R_a cease but the persistence-strengthening effects of prior stimulus-reinforcer pairings remain in effect (i.e., NCR increases the likelihood of resurgence of destructive behavior, despite the fact that the more immediate effects of NCR are typically a reduction in destructive behavior). The model operationalizes this relationship as the combination of baseline rate of reinforcement (*r*) and alternative reinforcement rate (R_a), which is consistent with the BMT contention that all reinforcement, whether response dependent, independent (e.g., NCR), or contingent on another response (e.g., DRA), contributes to the persistence of a response that occurs in that context (Nevin et al., 1990). Fortunately, the model also provides clear quantitative guidance on how NCR procedures might be altered in order to decrease resistance to NCR treatment and mitigate treatment relapse during periods of EXT.

Solutions to Limitations of Noncontingent Reinforcement

If the two limitations of NCR posed by BMT are accurate, then they suggest specific refinements for NCR that may increase the effectiveness of this intervention. The first potential refinement of NCR based on the resurgence model would be to include procedures designed to increase the saliency of the change from contingent reinforcement to NCR, such as pairing time-based reinforcer deliveries with discriminative features that are distinct from the features of the reinforcers delivered contingent on destructive behavior during baseline (e.g., changing the color of an iPad to bright green during NCR for a child whose destructive behavior was found to be reinforced by contingent access to a white iPad). Altering the saliency or discriminability of NCR should affect parameter *d* in the equation. Parameter *d* represents discriminability, or generalization decrement (Nevin et al., 2001) where greater *d* values suggest higher saliency in changes from contingent reinforcement to NCR and EXT. When conditions are assumed to be relatively discriminable, NCR and EXT effects are predicted to proceed more rapidly.

Second, when destructive behavior is maintained by automatic reinforcement, NCR is prescribed with alternative, nonfunctional reinforcers because the reinforcer that maintains destructive behavior cannot easily be accessed or withheld. Research on BMT suggests that destructive behavior may be more resistant to change when NCR is implemented without EXT (as is commonly done for behaviors maintained by automatic reinforcement) relative to when NCR is implemented with EXT (as is commonly done for behaviors maintained by social consequences). If, as the resurgence model suggests, NCR implemented without EXT results in greater resurgence of destructive behavior than when NCR is implemented with EXT, then NCR should be implemented with EXT whenever possible (e.g., using response blocking to prevent destructive behavior from contacting sensory reinforcement). Comparing the effects of NCR implemented with and without EXT should affect Parameter r in the equation.

Purpose

The purpose of this dissertation is to directly test the quantitative and theoretical predictions of BMT broadly, and the model of resurgence developed by Shahan and Sweeney (2011) specifically, on operant response persistence and resurgence using a human-operant preparation. This is important for both behavioral research and clinical practice. Events that commonly occur in the natural environment may impede delivery of NCR as scheduled (e.g., caregivers are attending to infant siblings). Therefore minimizing persistent destructive behavior and treatment relapse are crucial for long-term positive outcomes in individuals with destructive behavior.

Chapter 1 tests the first solution to NCR proposed by the resurgence model, which consists of increasing the discriminability between contingent reinforcement and NCR, and subsequently assessing levels of resurgence following this discriminability manipulation. Chapter 2 tests the second solution to NCR by comparing NCR implemented with and without EXT on levels of resurgence when all reinforcement is withdrawn. Chapter 3 integrates the discussion of this research in relation to the extant literature on resurgence, and states the implications of these findings in the broader context of strategies used to mitigate treatment relapse for severe destructive behavior.

CHAPTER 1: NONCONTINGENT REINFORCEMENT AND DISCRIMINABILITY

Introduction

Contingency discriminability refers to the immediacy with which a participant's behavior changes in response to changes in reinforcement contingencies or stimulus conditions (Mazur, 2013). An example of a contingency change that is likely to be highly discriminable would be a shift from continuous reinforcement to EXT, because frequent reinforcer deliveries would occur in the former schedule, and no reinforcer deliveries would occur in the latter schedule. By contrast, a shift from a lean VI schedule to a similarly lean VT schedule would likely be much less discriminable because each schedule would involve episodic reinforcer deliveries (Nevin & Shahan, 2011). Accordingly, Nevin et al. (2001) found that when they changed multiple VI-VI schedules to multiple VT-VT schedules that produced NCR at rates equal to the VI-VI baseline, responding was more persistent during NCR, and this effect became more significant as VI and VT schedules became denser.

With children with autism, Koegel and Rincover (1977) reinforced simple gross-motor tasks (e.g., clapping hands) with food and praise and subsequently evaluated how discriminability affected behavioral persistence during EXT. Following teaching, Koegel and Rincover introduced EXT in one condition and EXT plus NCR (after every 20^{th} trial during EXT) in another condition and found that responding persisted for many more trials during EXT plus NCR than after similar training with EXT only. They suggested that presenting NCR during EXT made the EXT environment more similar to the baseline environment, thereby decreasing discriminability and promoting behavioral persistence.

Some authors have attributed the persistence of responding under NCR schedules to unprogrammed contiguity between responding and reinforcement, or adventitious reinforcement (e.g., Catania & Keller, 1981). That is, because the reinforcer is delivered on a time-based schedule, it may coincidentally be delivered in close proximity to the target behavior (cf. Vollmer, Ringdahl, Roane, & Marcus, 1997). Alternatively, persistence of responding during

NCR may more often be due to the presentation of response-independent reinforcers that decrease contingency discriminability (Koegel & Rincover, 1977; Nevin et al., 2001; Nevin & Shahan, 2011; Rescorla & Skucy, 1969; Williams & Williams, 1969). That is, when the initial change from contingent reinforcement to NCR is not salient, responding may persist for prolonged periods. For example, if a child has historically received adult attention for engaging in disruptive behavior and caregivers subsequently implement NCR wherein attention is periodically given freely, independent of disruptive behavior, there typically are no environmental stimuli that signal to the child that the contingency for access to attention has changed. In these cases, destructive behavior may be more persistent during NCR, and this is especially true if reinforcers are delivered at the same rate as baseline (Nevin et al., 2001; Nevin & Shahan, 2011). This represents a stark contrast to other commonly used behavior-reductive procedures, such as FCT wherein a number of changes in stimulus conditions may enhance contingency discriminability (e.g., reinforcers no longer follow destructive behavior, the individual is typically prompted to emit a novel alternative response, reinforcers follow that alternative response, and the density of reinforcement typically increases to a fixed-ratio [FR] 1 schedule).

Contingency discriminability may also provide additional insight for some findings in the applied literature on NCR. For example, Carr, Bailey, Ecott, Lucker, and Weil (1998) conducted a parametric analysis of response decreases associated with different magnitudes of NCR. They taught five adults with intellectual disability to deposit poker chips into a large cylinder and reinforced this response with food on a variable-ratio (VR) 3 or VR-5 schedule during baseline. Next, they exposed participants to high-, medium-, and low-magnitude NCR schedules (defined by differing amounts of food in each condition) with the NCR schedule yoked to the baseline rate of reinforcer delivery. Carr et al. found that high-magnitude-NCR schedules produced large reductions in response rates, medium-magnitude schedules produced smaller reductions, and low-magnitude schedules, which matched the magnitude of contingent reinforcement delivered during baseline, produced no noticeable reductions in responding. The authors concluded that magnitude of reinforcement was an important variable in determining the effectiveness of NCR.

Another variable that may have contributed to the effects observed by Carr et al. (1998) is contingency discriminability. That is, the investigators delivered reinforcement at the same rate and magnitude during the low-magnitude-NCR condition as they delivered during the contingent-reinforcement baseline (e.g., a third of a cookie). By contrast, the investigators increased the magnitude of reinforcement three-fold in the medium-magnitude condition (e.g., one cookie) and six-fold in the high-magnitude condition (e.g., two cookies), and each increase in the magnitude of reinforcement probably increased the discriminability of the contingency change. Thus, the high level of response persistence that the investigators observed in the low-magnitude condition may have (in part) been due to low discriminability between the baseline and the low-magnitude-NCR condition. Further, the investigators observed the greatest reductions in responding in the high magnitude condition where contingency discriminability was likely the greatest. Other examples in which contingency discriminability may have influenced the results can be found in the applied literature on NCR (e.g., Hagopian et al., 1994; Ringdahl, Vollmer, Borrero, & Connell, 2001).

Although the empirical support regarding the effectiveness of NCR interventions is quite strong (Carr et al., 2009; Richman et al., 2015), conceptual and quantitative derivations of BMT, along with some empirical findings, suggest that NCR interventions may promote persistence of responding and increase resistance to change in part due to low contingency discriminability (Shahan & Sweeney, 2011; Nevin & Shahan, 2011). In Shahan and Sweeney's BMT model of resurgence, discriminability is represented by a free parameter, with lower values representing relatively poorer discriminability and higher values representing relatively better discriminability. The model predicts that EXT proceeds more rapidly when this discriminability parameter is relatively large (e.g., $d = .01$) and EXT proceeds more slowly when the discriminability parameter is relatively small (e.g., $d = .001$). That is, less contingency discriminability generally produces greater response persistence during EXT. Therefore, procedures designed to enhance discriminability when NCR is implemented may facilitate quicker reductions in responding. By enhancing discriminability, treatments involving NCR might proceed more rapidly. For instance, in a translational study, Podlesnik and Fleet (2014) found that signaling response-independent reinforcers in one component of a two component multiple schedule resulted in greater reductions in responding during an EXT-only test condition relative to a control condition where response-dependent reinforcers were not signaled (when signals were 5 s in duration or greater).

Shahan and Sweeney's (2011) model of resurgence also predicts that when NCR is used as a strategy to decrease responding and then is subsequently suspended, as might occur in the home environment when a parent is busy and unable to deliver NCR for a period of time, resurgence of the target response is likely to occur. Fortunately, this model also predicts that resurgence can be mitigated during such unplanned periods of EXT if the NCR schedule is highly discriminable from the schedule of contingent reinforcement delivered during baseline. In addition, enhancing discriminability of reinforcer deliveries during NCR may also subsequently enhance the discriminability of the contingency change between NCR and periods of EXT.

Our main purpose Study 1 was to evaluate a potential refinement of NCR designed to increase the saliency of the change from contingent reinforcement to NCR thereby decreasing persistence of target responding in the salient NCR condition. We attempted to systematically vary the discriminability of NCR while holding other relevant reinforcement parameters constant (e.g., rate, magnitude, delay, quality). Our secondary purpose for this study was to test whether increasing the discriminability of NCR would lower resurgence of the target response during a subsequent EXT challenge, as predicted by Shahan and Sweeney's (2011) resurgence model.

Method

Participants and Settings

Four children with a diagnosis of autism spectrum disorder participated. Gen, a 5-year-old girl, communicated using full sentences. Kevin and Alex were 4-year-old twin brothers who communicated using three- to four-word utterances. Jack, a 5-year-old boy, communicated using full sentences. All participants completed all or most activities of daily living independently.

The therapist conducted sessions for Gen, Kevin, and Alex in a therapy room at an outpatient clinic of a university-based autism center. Therapy rooms contained only a table, two chairs, a laptop computer, and the relevant response materials. The therapist conducted Jack's sessions in a living space in his home. The living space contained a table, two chairs, a laptop computer, the relevant response materials, and occasionally other unrelated items (e.g., bed, lamp, clothing), and the therapist compensated for these items either by placing them off to the side of the room or by conducting the session in another part of the room.

Stimulus Preference Assessment and Reinforcer Variants

We conducted a paired-choice stimulus preference assessment using the procedures described by Fisher et al. (1992) at the onset of the study to identify a preferred item that presumably functioned as a reinforcer when the participant interacted with the apparatus. We selected items for inclusion in the preference assessment based on caregiver and therapist report.

Once we selected a potential reinforcer based from the results of the preference assessment, we created two variants of the reinforcer in order to vary the discriminability of our NCR intervention. For example, the preference assessment identified M&Ms as highly preferred for Kevin and Jack. Therefore, we used different colored M&Ms (red and green) to increase the discriminability of our baseline (e.g., red M&Ms delivered contingently) and intervention (e.g., green M&Ms delivered on a NCR schedule) conditions.

Reinforcer Substitutability Assessment

We conducted a reinforcer substitutability assessment to determine whether the two variants of each participant's reinforcers (e.g., green versus red M&Ms) were of approximately equal reinforcement value. During the assessment, we presented two identical buttons (described below) on a table directly in front of the participant. Each variant of the reinforcer was associated with one button (e.g., responses on one button produced red M&Ms; responses on the other button produced green M&Ms). We randomly selected one button to produce reinforcement on a FR-5 schedule (e.g., green M&Ms delivered after every fifth response) and the other button to produce reinforcement (e.g., red M&Ms) on a progressive-ratio (PR) schedule. The button associated with the PR schedule produced reinforcement on an FR-1 schedule during the first trial and the response requirement increased by one on each subsequent trial (i.e., FR 2, FR 3, FR 4, etc.) until we observed a clear shift in preference from the PR to the FR schedule. Next, we repeated the substitutability assessment with the schedules reversed (e.g., if we delivered green M&Ms on the FR schedule in the first assessment, we delivered green M&Ms on the PR schedule in the second assessment). The purpose of conducting this assessment twice in this manner was to demonstrate that each variant of the reinforcer was substitutable for the other.

Apparatus

For Gen, Kevin, and Jack, we used an Orby™ button-style adaptive switch developed by Origin Instruments as the response apparatus. The button switch was 6.4 cm in diameter and required 99.2 g of force to depress completely. We connected the button switch to a laptop computer, which recorded all responses using a DELL PC-compatible computer running DataPal software, which was located adjacent to the participant but out of reach or view.

For Alex, the response apparatus was a 22.9-cm by 12.7-cm box with a 7.6 cm diameter opening on the top. Located next to the box was a clear plastic bag containing several poker chips so that each target response involved taking one or more chips from the bag and depositing them in the box (adapted from the task used by Carr et al. 1998). During Jack's sessions, experimenters collected data manually using DataPal software on laptop computers.

We placed a 10.2-cm by 5.1-cm index card next to the response apparatus so that it was visible to the participant. On one side of the card was a picture of one variant of the reinforcer (e.g., red M&M) and on the other side was a picture of another variant of the reinforcer (e.g., green M&M; see Figure 1). Each side of the card served to indicate which component of a compound multiple schedule was in effect (i.e., the schedule-correlated stimulus). The experimenter, who was seated across from the participant, rotated the card manually when prompted by the computer software. The experimenter blocked all attempts by the participant to touch or manipulate the index card. We further programmed the computer program to prompt the experimenter to deliver reinforcement at the scheduled time. We conducted experimental sessions with each participant for 1 to 2 hours per appointment and scheduled 3 to 5 appointments per week.

Response Measurement, Data Analysis, and Interobserver Agreement

For Gen, Kevin, and Jack, a response was defined as the complete depression of the button using only the participant's hand. Each response was separated by the removal of the hand from the button to allow the button to return to its neutral, non-depressed state. For Alex, a response was defined as dropping one or more poker chips into the box at one time. For example, whether he dropped one chip into the box or three at one time, each instance was recorded as the emission of a single response. We calculated the response rate for each component of each experimental session by dividing the number of responses the participant emitted in a component by the number of minutes that component was in effect during a session and multiplying the result by 60 (to produce the number of responses per hour). We also recorded the number of reinforcers delivered in a given component and calculated the reinforcement rate in a like manner. In addition, to account for differences in baseline response rates across baseline phases, we compared levels of responding during the NCR conditions and EXT only-phases expressed as both a proportion of baseline and a proportion of the preceding phase.

A second observer independently collected data from videotaped sessions on 33% of Alex's sessions. We calculated interobserver agreement by dividing the smaller obtained value by the larger obtained value for each session. Each quotient was then converted to a percentage. Interobserver agreement averaged 99% (range, 98% to 100%) for depositing poker chips into the box and 100% for number of reinforcers earned.

Experimental Design

We combined elements of a multiple-schedule design with a reversal design to evaluate the effects of discriminability on behavioral persistence during NCR and EXT. We randomly assigned the four participants in pairs so that we exposed two participants to the high discriminability sequence before the low discriminability sequence and the other two participants followed the opposite order. Figure 1 illustrates the experimental conditions and experimental sequence. We evaluated levels of responding in the following conditions: pre-training, multiple-schedule baseline, time-based reinforcement with high discriminability (NCR-HD), time-based reinforcement with low discriminability (NCR-LD) and EXT only.

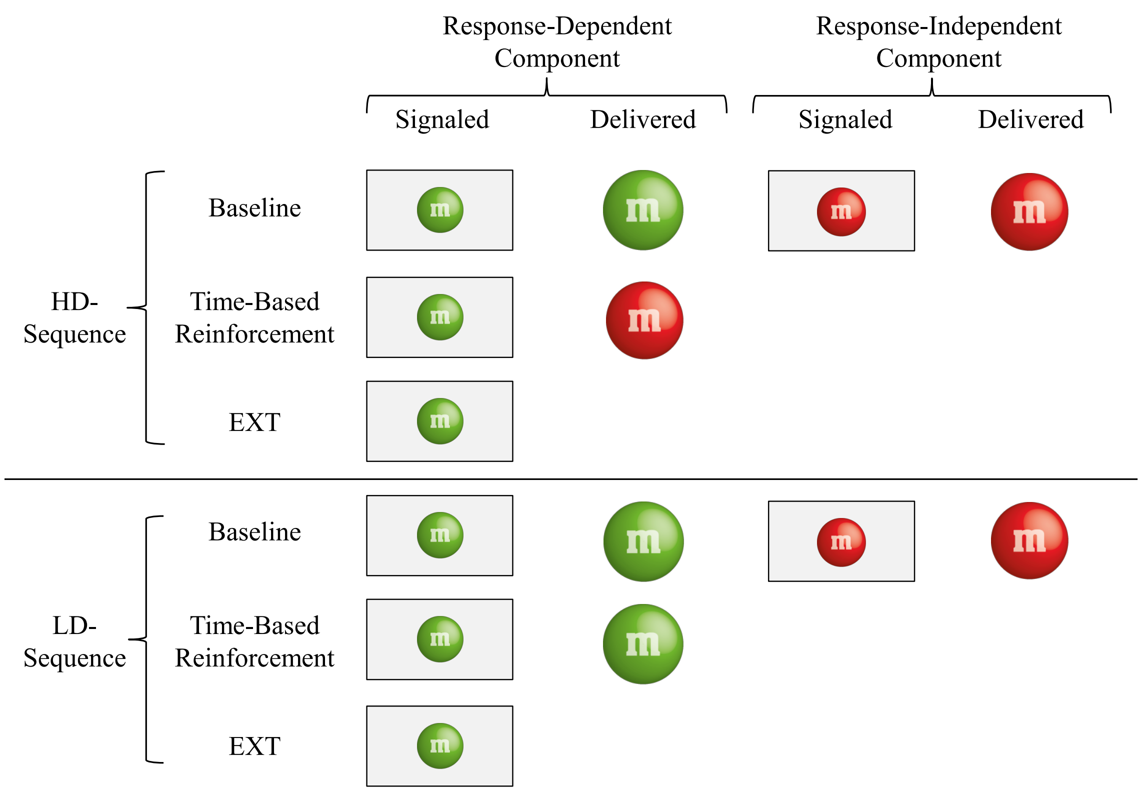

Figure 1. Experimental Arrangement. The experimental arrangement for each discriminability sequence including the signaled and delivered reinforcer for each phase (arrangement for Kevin and Jack displayed).

Procedure

Sessions during the multiple-schedule baseline phase lasted 10 min. During each session, the two components alternated in a quasi-random fashion with each component interval lasting 1 min, resulting in a total of 5 min of exposure to each component per session. We used one of the components of the multiple schedule (i.e., the one involving response-dependent reinforcement [RDC]) as the baseline against which we compared the effects of NCR. The purpose of the other component of the multiple schedule (i.e., the one involving response-independent reinforcement [RIC]) was to establish a history of NCR with one of the two variants of the reinforcer (e.g., a reinforcement history of red M&Ms delivered on a NCR schedule). Sessions in the NCR and EXT-only phases lasted 5 min because we evaluated the effects of NCR and EXT on responding in relation to the RDC of the multiple schedule, which lasted 5 min per session.

At the start of each session, the experimenter told the participant "Here is the [task], you can do as much or as little as you want." With participants for whom the preference assessment identified tangible items as potential reinforcers (toy horses for Gen and Play-Doh® for Alex), we paused the session clock for 15 s during the reinforcement interval so that the participant had a reasonable amount of time to consume the reinforcer. We removed the response materials during this 15-s reinforcement interval. Following this consumption period, the reinforcer was withheld and the session clock was resumed. For participants with edible reinforcers (M&Ms for Kevin and Jack), we did not pause the session clock, as consumption time was negligible.

Pretraining. We conducted pretraining to teach participants how to interact with the response apparatus appropriately and to ensure sustained responding on a VI schedule of reinforcement. We shaped the target response using the method of reinforcing successive approximations and then maintained the response on a VI 30-s schedule for at least one session prior to baseline. We repeated the pretraining following each EXT-only phase and prior to each baseline phase to mitigate potential sequence effects. During all pretraining sessions, we excluded the schedule-correlated stimuli (i.e., the index cards that signaled response-contingent or response-independent reinforcement).

Multiple-Schedule Baseline. In one component (RDC), we delivered one variant of the reinforcer on a VI 30-s schedule. The schedule-correlated stimulus in this component was a picture of the reinforcer variant on a 10.2-cm by 4.2-cm index card (e.g., we delivered green M&Ms contingently in the presence of the card showing a green M&M).

In a second component (RIC), we delivered the alternative variant of the reinforcer (e.g., red M&Ms) on a VT 30-s schedule in the presence of the alternative schedule-correlated stimulus (e.g., a picture of a red M&M on the index card). In addition, a 5-s resetting DRO was added to the end of the VT schedule to preclude temporal contiguities between responses and reinforcers (thus mitigating adventitious reinforcement), and to enhance the effectiveness of terminating the reinforcement contingency.

NCR-HD. We conducted all NCR-intervention sessions in the context of the RDC from baseline (see Figure 1). During this phase, responding no longer produced the reinforcer (i.e., EXT). The schedule-correlated stimulus from the RDC component of the multiple-schedule baseline (e.g., index card with a picture of a green M&M on it) remained in place. In the high-discriminability phase, we delivered the alternative variant of the reinforcer (e.g., red M&Ms) on a VT 30-s schedule. That is, we delivered the reinforcer with a history of response-independent delivery (originally associated with the RIC component of the multiple-schedule baseline) in a context with a history of response-dependent reinforcement (i.e., the RDC context from the multiple-schedule baseline). To enhance the effectiveness of NCR in this phase, we added a 5-s DRO to the end of the VT schedule to mitigate adventitious contiguous pairings of the target response followed by reinforcer delivery. We terminated this phase after the rate of responding decreased by 90% for two consecutive sessions relative to the mean rate of responding during baseline (i.e., the RDC component of the multiple-schedule baseline).

NCR-LD. We conducted this condition using procedures identical to those described above for NCR-HD with one exception. During NCR-LD, we delivered the same reinforcer variant that we delivered during the RDC component from multiple-schedule baseline (e.g., green M&Ms; see Figure 1).

EXT Only. Following each of the NCR-intervention phases, we conducted an EXT-only phase in the context of the RDC component of the multiple-schedule baseline. During this phase, all reinforcer deliveries ceased. In addition, the schedule-correlated stimulus from the RDC component of the multiple-schedule baseline (e.g., index card with a picture of a green M&M on it) remained in place. The purpose of this phase was to test whether increased discriminability during NCR-HD would reduce response persistence during a subsequent EXT challenge relative to the NCR-LD condition. This phase ended when responding ceased for three consecutive sessions.

Results

For Gen, the preference assessment identified toy horses as highly preferred, and we used orange and purple horses as the two variants (Figure 2). For Alex, the preference assessment identified Play-Doh as highly preferred, and we used blue and orange Play-Doh as the two variants (Figure 3). For Kevin (Figure 4) and Jack (Figure 5), the preference assessment identified M&Ms as highly preferred, and we used green and red M&Ms as the two variants.

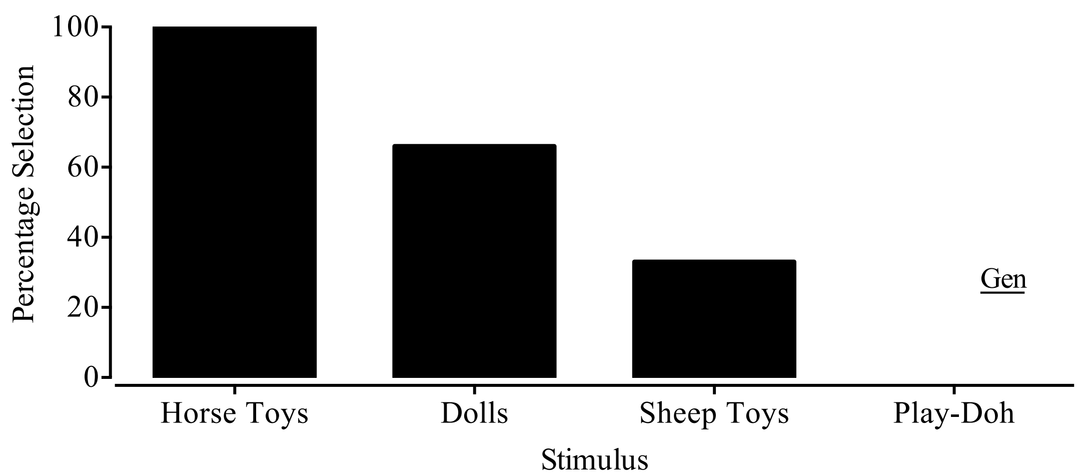

Figure 2. Preference Assessment Results for Gen.

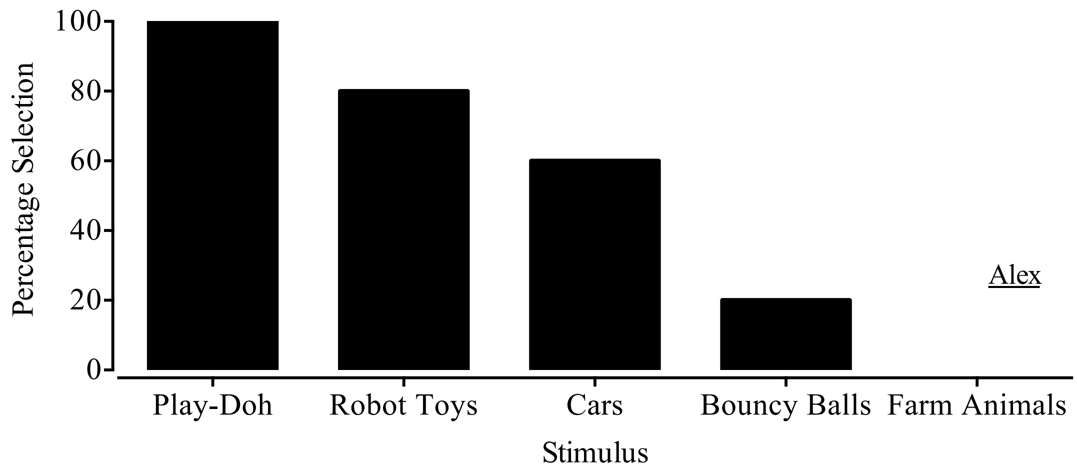

Figure 3. Preference Assessment Results for Alex.

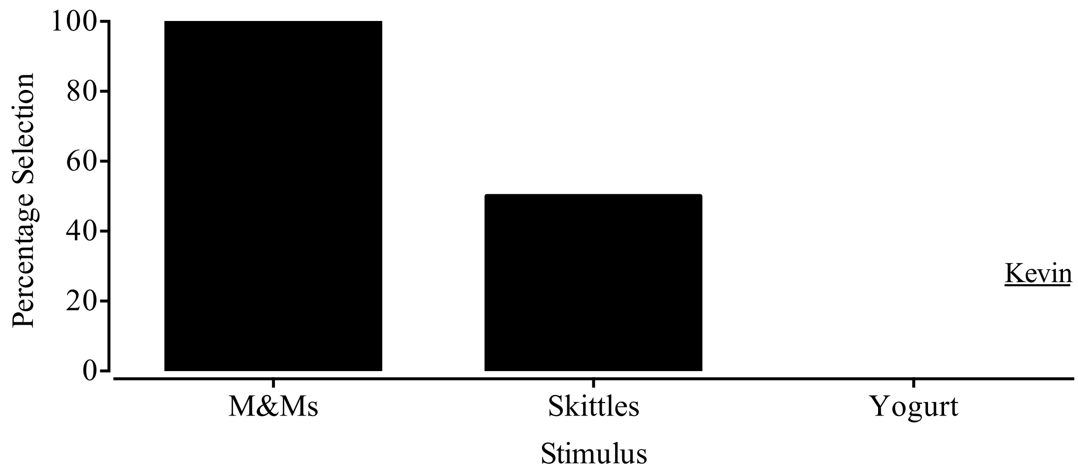

Figure 4. Preference Assessment Results for Kevin.

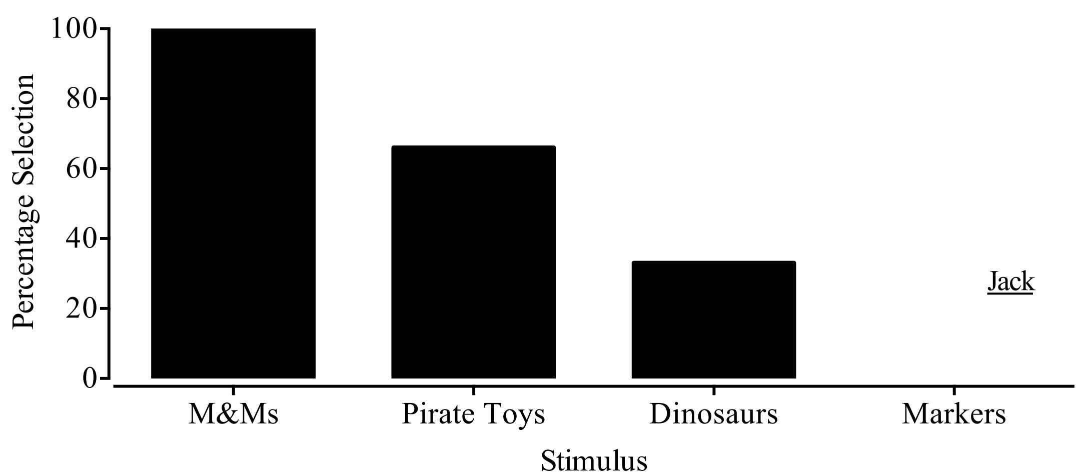

Figure 5. Preference Assessment Results for Jack.

For all participants, results indicated that the two variant reinforcers were reasonably substitutable. All participants initially allocated responding to the reinforcer variant associated with the PR schedule when it had a low response requirement but switched to FR schedule as the response requirement of the PR schedule increased. Gen (Figure 6) and Jack (Figure 7) shifted their responding to the FR-5 schedule between the 5th and 7th PR value. Kevin (Figure 8) did so at the 12th and 5th PR value. Alex (Figure 9) showed more variability in response allocation during the intermediate PR values (i.e., more switching between schedules); however, he showed a consistent shift to the FR-5 schedule at the 11th and 9th PR value.

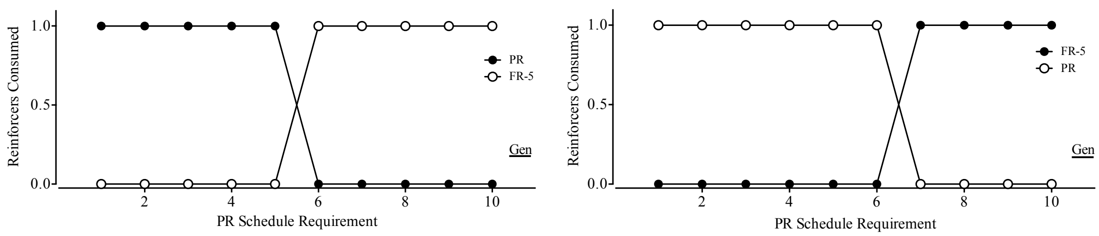

Figure 6. Substitutability Assessment Results for Gen.

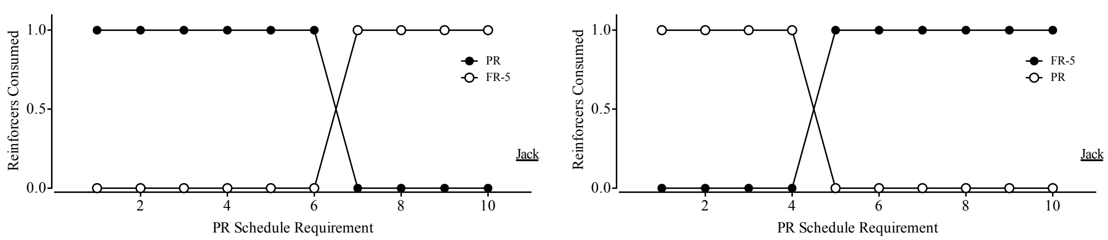

Figure 7. Substitutability Assessment Results for Jack.

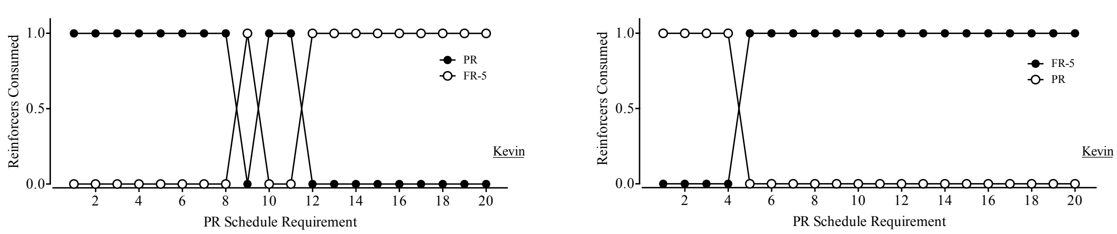

Figure 8. Substitutability Assessment Results for Kevin.

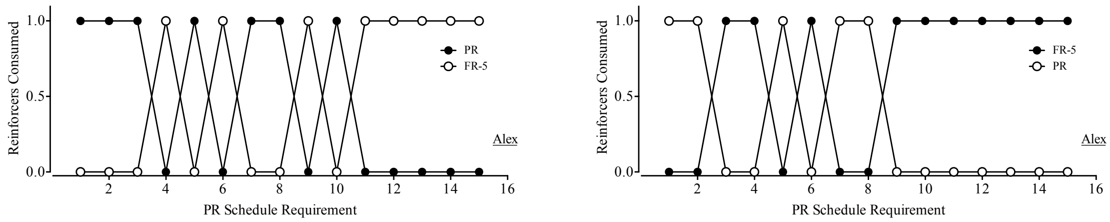

Figure 9. Substitutability Assessment Results for Alex.

Figure 10 displays the results of Gen's discriminability comparison and test for resurgence during the EXT-only condition presented as responses per hour. During the multiple-schedule baseline, Gen engaged in highly discriminated responding with responses occurring almost exclusively during the RDC of the multiple schedule. When comparing responding in the two NCR phases, Gen showed a more immediate decrease in responding during NCR-HD relative to NCR-LD. In addition, her responding decreased to the criterion level (i.e., 90% reduction) more quickly during NCR-HD relative to NCR-LD.

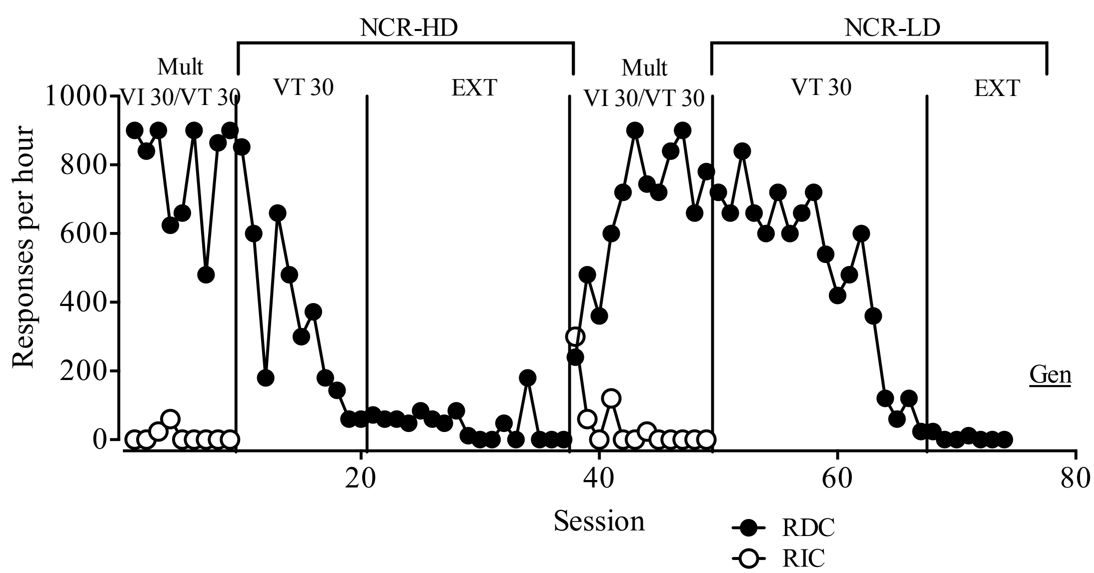

Figure 10. Primary Results of NCR discriminability comparison with Gen.

To further analyze potential differences in levels of behavioral persistence during the NCR and EXT-only phases, we conducted Fisher's (1935) randomization test for each NCR and EXT-only phase. Fisher's randomization test is a non-parametric statistical method used to determine the likelihood of obtaining results due to chance and provides a test for significance between two or more conditions. In the NCR and EXT-only phases, we used a two-tailed Fisher randomization test to analyze the proportional data during the first five sessions only. This criterion was used because (a) we wanted to evaluate the immediate effects of enhancing discriminability during NCR; (b) treatment relapse (e.g., resurgence) is a phenomenon that is typically observed when EXT is first introduced for a target response; and (c) we wanted to better identify potential differences across experimental conditions, which may otherwise be obscured by zero rates of responding during NCR or EXT-only phases. When comparing the means for the two NCR conditions using the randomization test with Gen, we observed the difference to be statistically significant ($p < .04$).

Kevin (Figure 11) displayed higher levels of responding in the RDC of the multiple-schedule baseline (M = 202.8 responses per hour [RPH]) relative to the RIC (M = 50.4 RPH). When comparing responding in the two NCR phases, Kevin showed immediate decreases in responding during NCR-HD, but responding persisted at relatively high rates during NCR-LD. The difference between the means for these two conditions was statistically significant ($p < .01$).

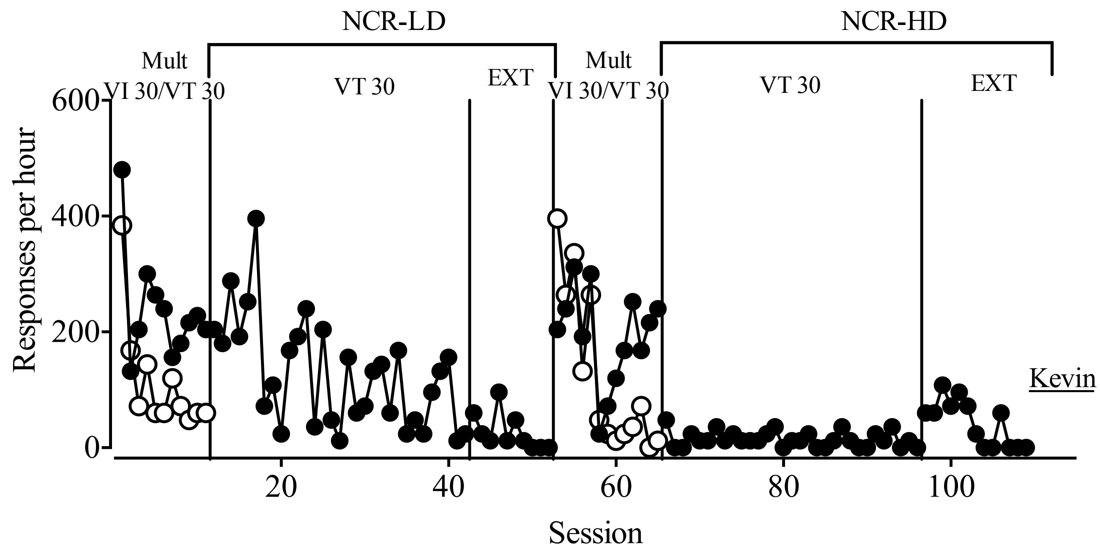

Figure 11. Primary Results of NCR discriminability comparison with Kevin.

Alex (Figure 12) showed a response pattern similar to Gen and Kevin, but his discriminated responding between the RDC and RIC of the multiple-schedule baseline developed more slowly (M = 685.2 RPH during RDC; M = 357.6 RPH during RIC). Alex displayed more immediate reductions in the target response and reached the target criterion in fewer sessions during NCR-HD relative to NCR-LD. The difference between the means for these two conditions was statistically significant ($p < .01$).

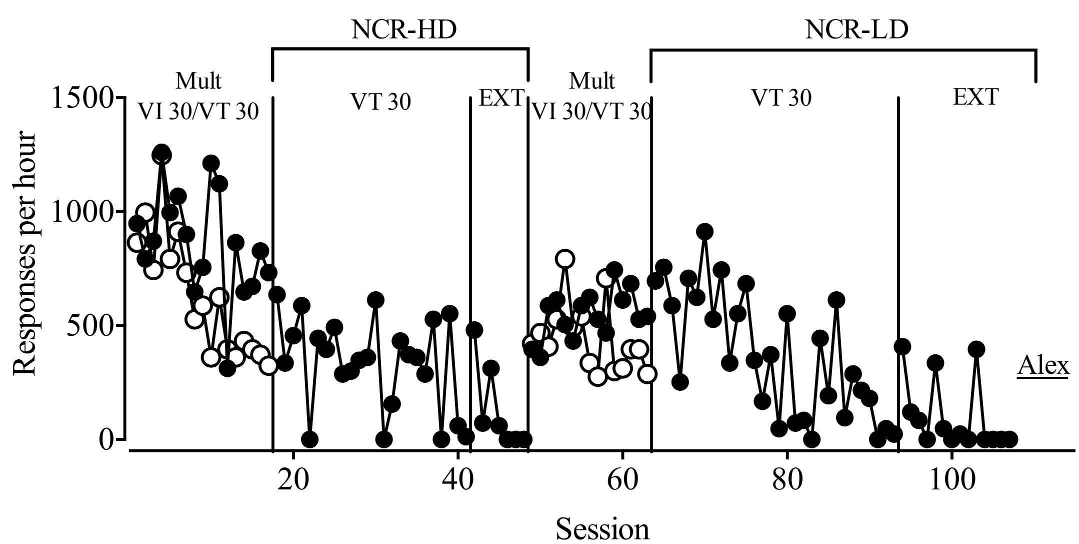

Figure 12. Primary Results of NCR discriminability comparison with Alex.

Jack (Figure 13) displayed clearly discriminated responding during the final five sessions of each baseline phase, with almost exclusive responding occurring during the RDC (*M* = 136.8 RPH during RDC; *M* = 3.6 RPH during RIC). He showed a large and fairly immediate reduction in responding during both the NCR-HD and NCR-LD phases, and the difference between the means for these two conditions did not approach statistical significance (*p = .48*).

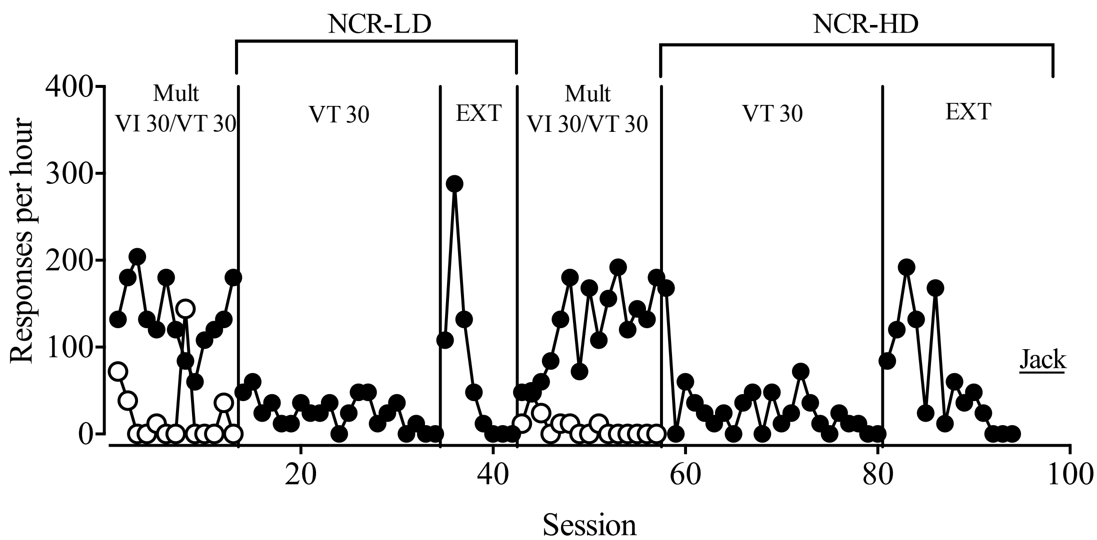

Figure 13. Primary Results of NCR discriminability comparison with Jack.

For each participant, we examined the levels of responding during the two NCR conditions as a proportion of baseline responding. As can be seen in Figure 14, Gen's proportional responding decreased much more rapidly and reached the terminal criterion in fewer sessions during NCR-HD relative to NCR-LD. Figure 15 shows the proportional rates of responding for Kevin and his proportional responding decreased much more rapidly and reached the terminal criterion in fewer sessions during NCR-HD relative to NCR-LD. As can be seen in Figure 16, Alex's proportional responding decreased more rapidly and reached the terminal criterion in fewer sessions during NCR-HD relative to NCR-LD. Jack showed similarly rapid and marked reductions in responding during both NCR conditions (Figure 17).

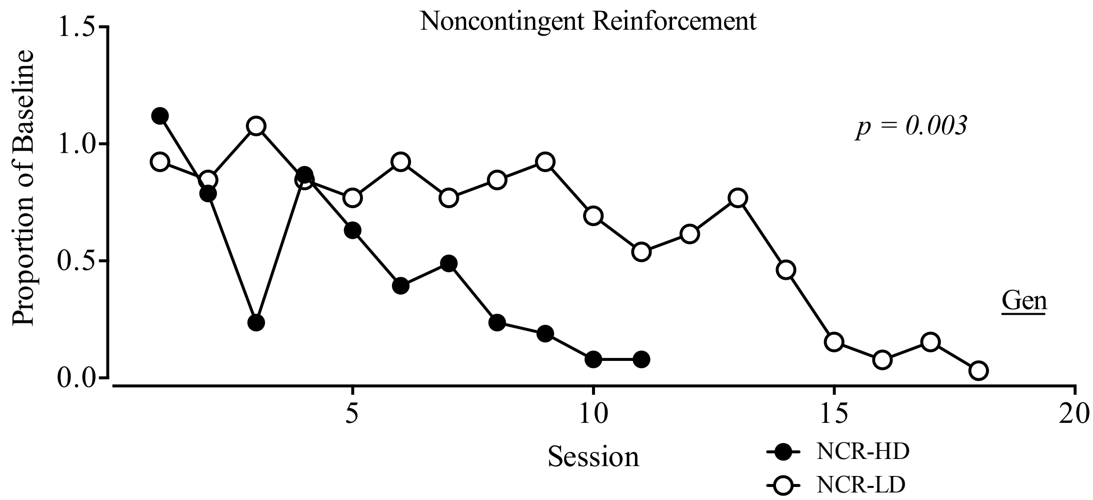

Figure 14. Proportional Responding during NCR phases for Gen.

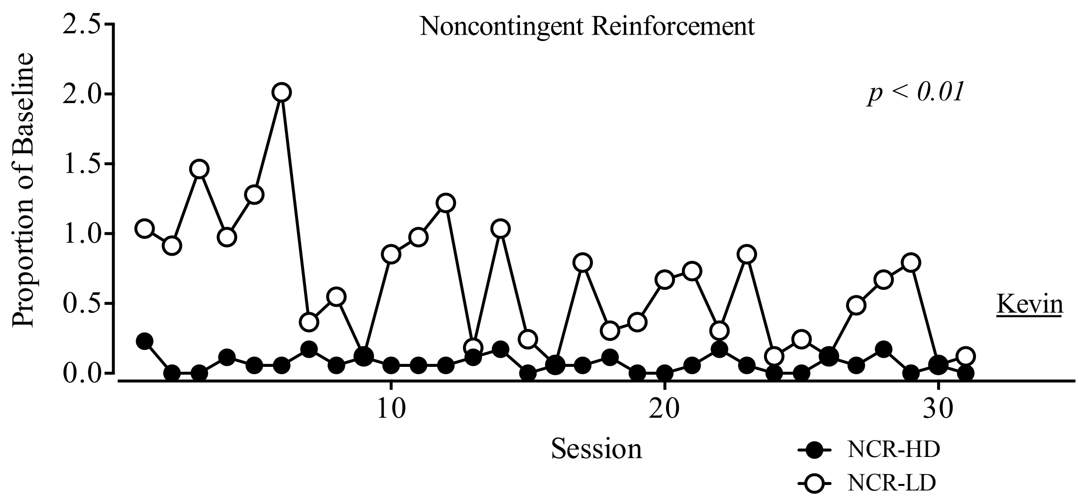

Figure 15. Proportional Responding during NCR phases for Kevin.

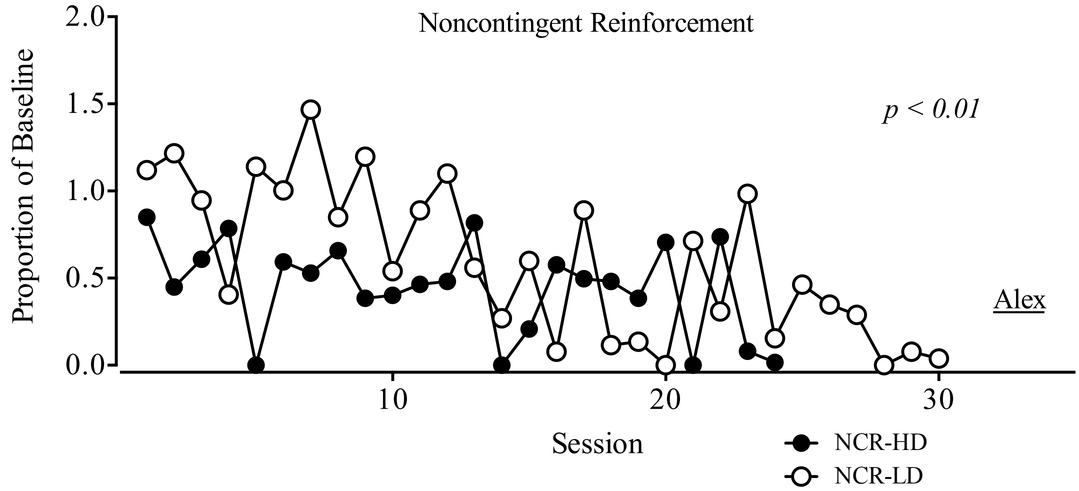

Figure 16. Proportional Responding during NCR phases for Alex.

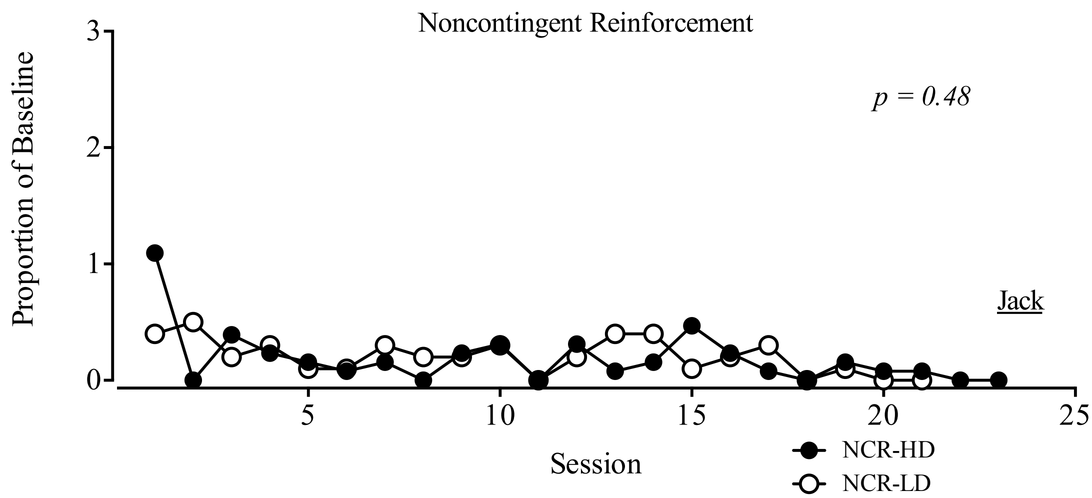

Figure 17. Proportional Responding during NCR phases for Jack.

Typically, resurgence is defined by the magnitude of incremental responding during EXT proportional to the baseline response rate (Podlesnik & Shahan, 2009). However, in cases where response rates during baseline are similar, and the comparison phase of interest is the alternative reinforcement phase (e.g., NCR), it may be appropriate to evaluate resurgence proportional to the phase immediately preceding the EXT-only test phase (Cançado, Abreu-Rodrigues, & Aló, 2015; da Silva, Maxwell, & Lattal, 2008; Lattal & Wacker, 2015). Moreover, Cançado et al. (2015)

suggested that in addition to magnitude, frequency of the response (i.e., the number of sessions in which the response occurs) might also be an appropriate measure of resurgence. Therefore, three criteria were used to evaluate resurgence during the EXT only phase: (a) proportion of baseline responding, (b) proportion of the previous NCR discriminability phase, and (c) the number of sessions in which responding continued to occur until we observed three consecutive sessions with zero rates of responding. In addition, the two NCR conditions were analyzed as a proportion of baseline. Table 1 summarizes whether greater resurgence was observed following NCR-HD or NCR-LD, during the EXT only phase, for each participant using the three criteria adopted to evaluate resurgence.

Participant	Magnitude: Proportion of Baseline	Magnitude: Proportion of Time-based Reinforcement	Frequency: Number of Sessions with Responding
Gen	No difference*	NCR-HD*	NCR-HD
Kevin	No difference*	NCR-HD*	NCR-HD
Alex	No difference	NCR-LD	NCR-LD
Jack	No difference	No difference	NCR-HD

Table 1. Resurgence during EXT only following NCR. NCR-HD = greater resurgence observed following NCR-HD; NCR-LD = greater resurgence observed following NCR-LD; No difference = no difference in resurgence between NCR-HD and NCR-LD; * = a statistically significant difference

For Gen, Figure 18 shows small, but statistically significant differences between the levels of responding in the EXT-only conditions that followed NCR-HD and NCR-HD when expressed as a proportion of baseline ($p < .01$). However, when expressed as a proportion of the prior NCR phase (Figure 19), the differences become more apparent and show increased response persistence in the EXT-only condition that followed NCR-HD + EXT relative to the one that followed NCR-LD + EXT ($p < .01$).

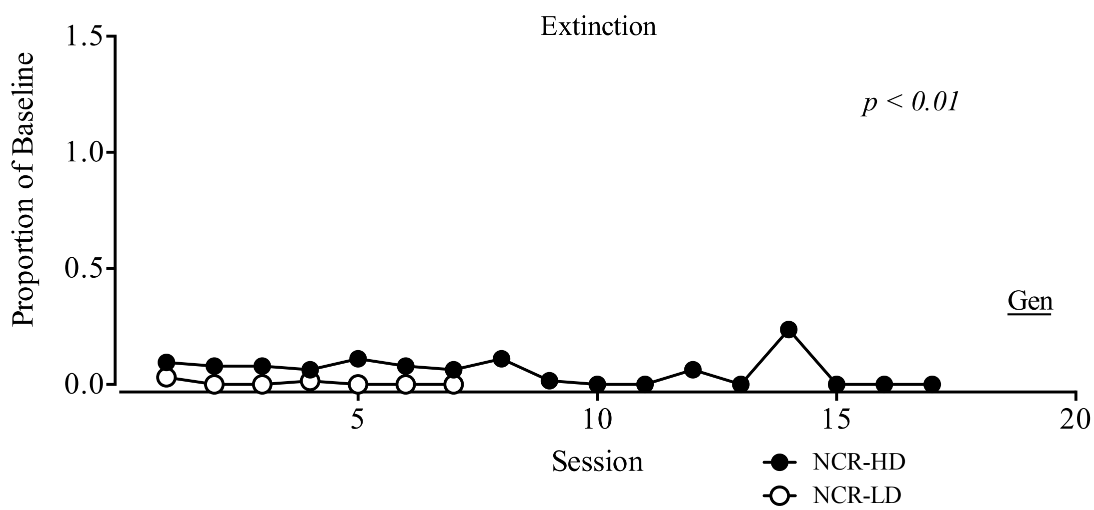

Figure 18. Responding During EXT only for Gen (Proportion of Baseline).

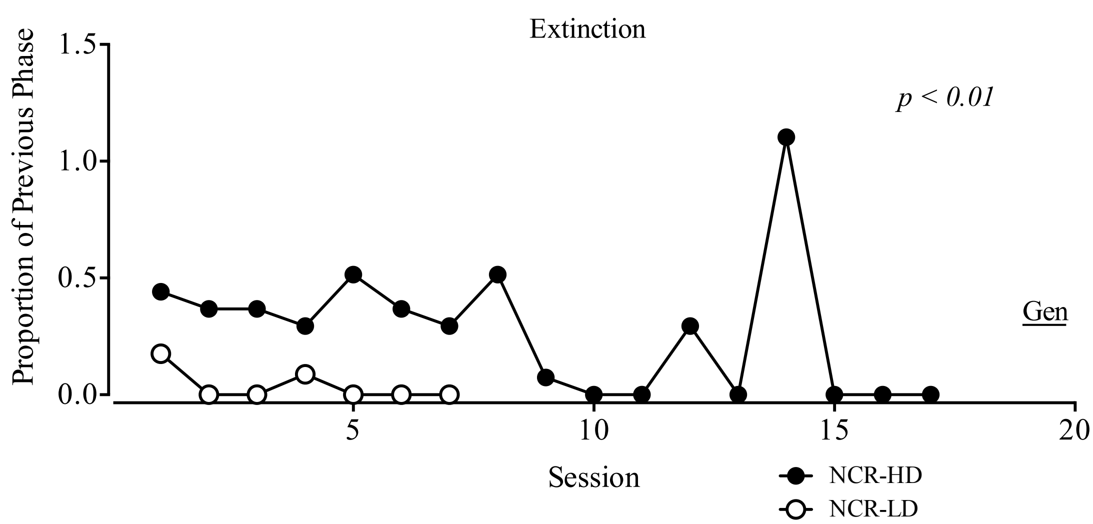

Figure 19. Responding During EXT only for Gen (Proportion of Prior NCR Phase).

For Kevin, Figure 20 shows small, but statistically significant differences between the levels of responding in the EXT-only conditions that followed NCR-HD and NCR-HD when expressed as a proportion of baseline (*p = .04)*. However, when expressed as a proportion of the prior NCR phase (Figure 21), the differences become more apparent and show increased response persistence in the EXT-only condition that followed NCR-HD relative to the one that followed

NCR-LD ($p < .01$). Thus, for both Gen and Kevin, although our manipulation designed to make NCR more discriminable in NCR-HD produced more rapid and greater reductions in responding while we implemented this NCR intervention, when we removed it during the EXT-only phase, the discriminability manipulation in NCR-HD appeared to increase response persistence for these two participants.

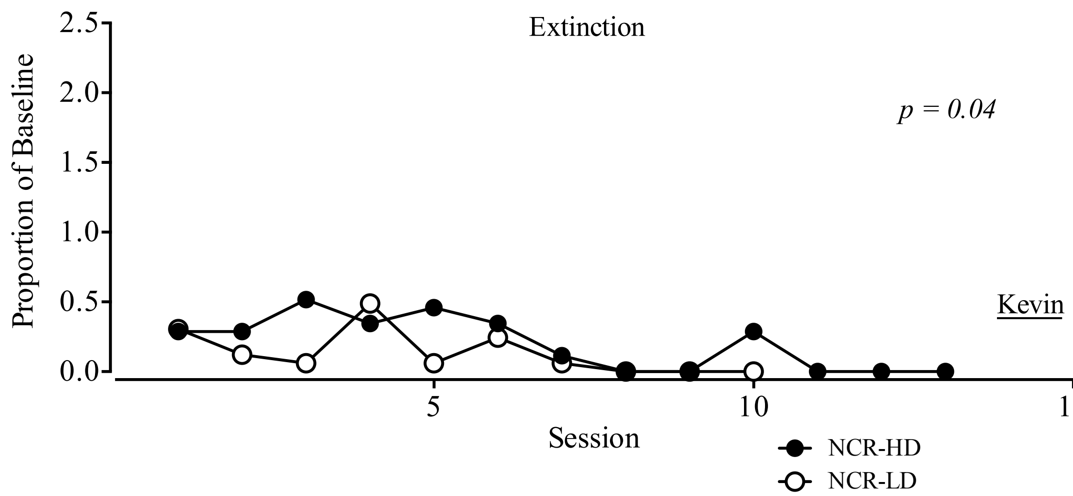

Figure 20. Responding During EXT only for Kevin (Proportion of Baseline).

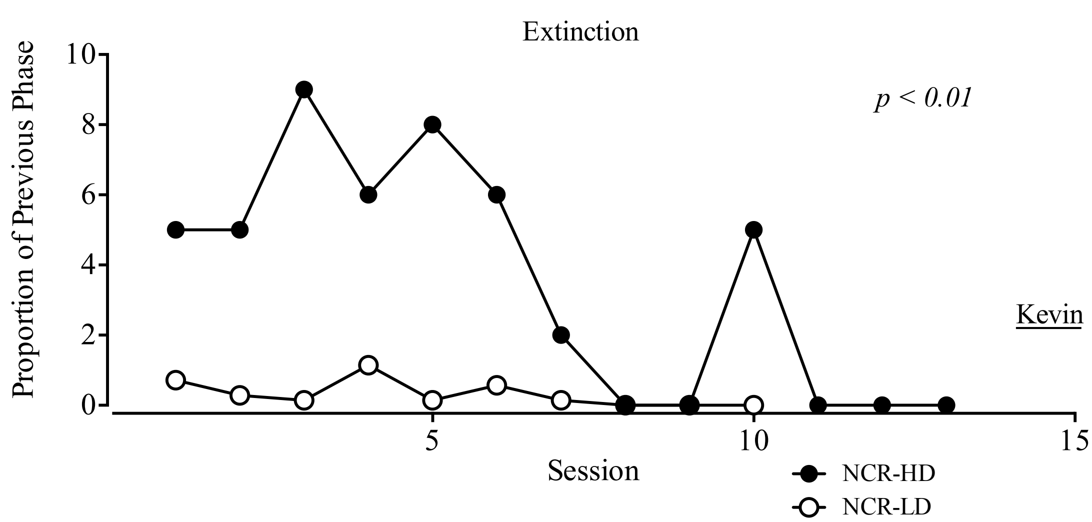

Figure 21. Responding During EXT only for Kevin (Proportion of Prior NCR Phase).

As can be seen in Figure 22 and Figure 23, Alex's proportional responding showed slightly less persistence in NCR-HD and reached the terminal criterion in fewer sessions relative to NCR-LD, though the mean difference did not reach statistical significance for either proportional-responding measure.

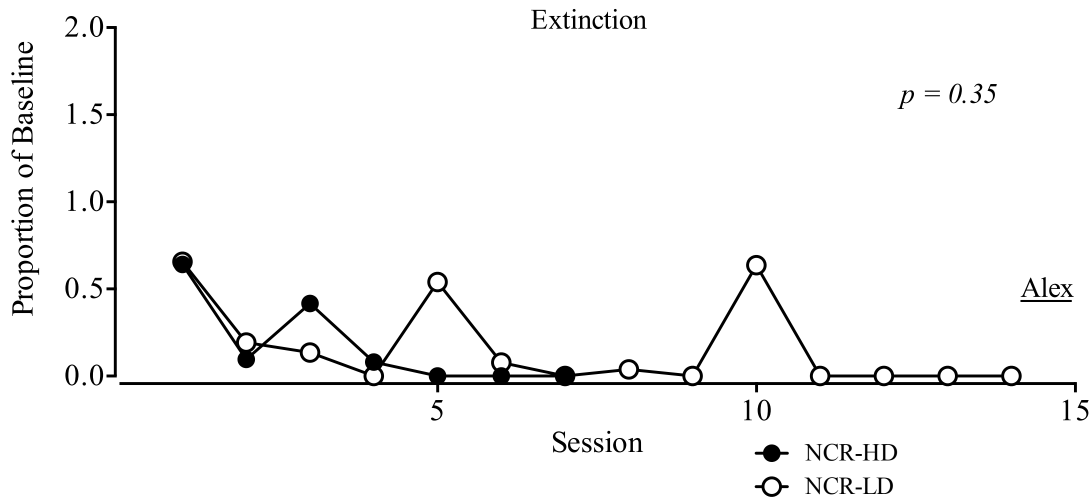

Figure 22. Responding During EXT only for Alex (Proportion of Baseline).

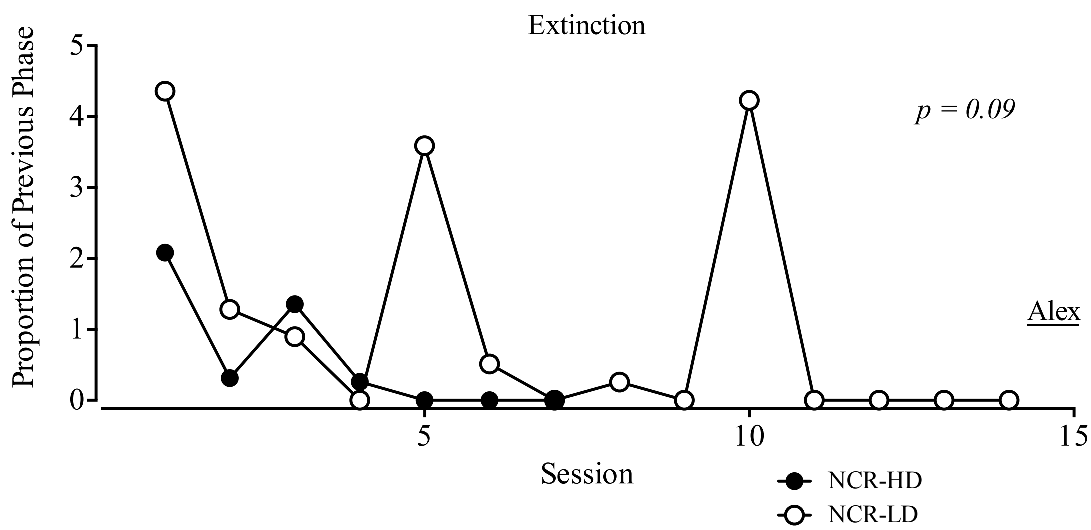

Figure 23. Responding During EXT only for Alex (Proportion of Prior NCR Phase).

Jack showed clear and roughly equivalent increases in proportional responding when we withdrew each NCR intervention during the EXT-only condition regardless of whether we measured responding proportional to baseline (Figure 24) or proportional to the previous NCR phase (Figure 25). The small differences between the means for the two proportional measures failed to reach statistical significance.

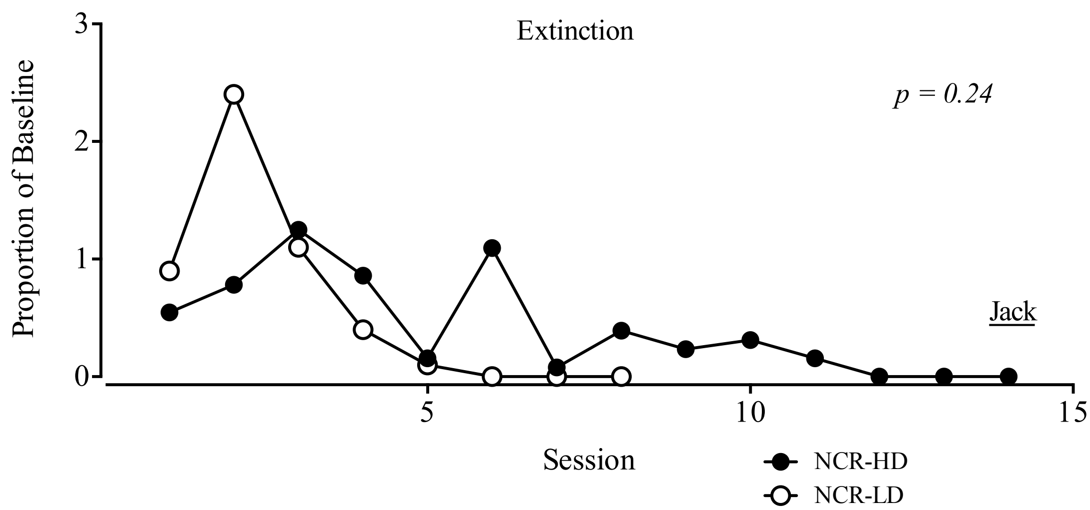

Figure 24. Responding During EXT only for Jack (Proportion of Baseline).

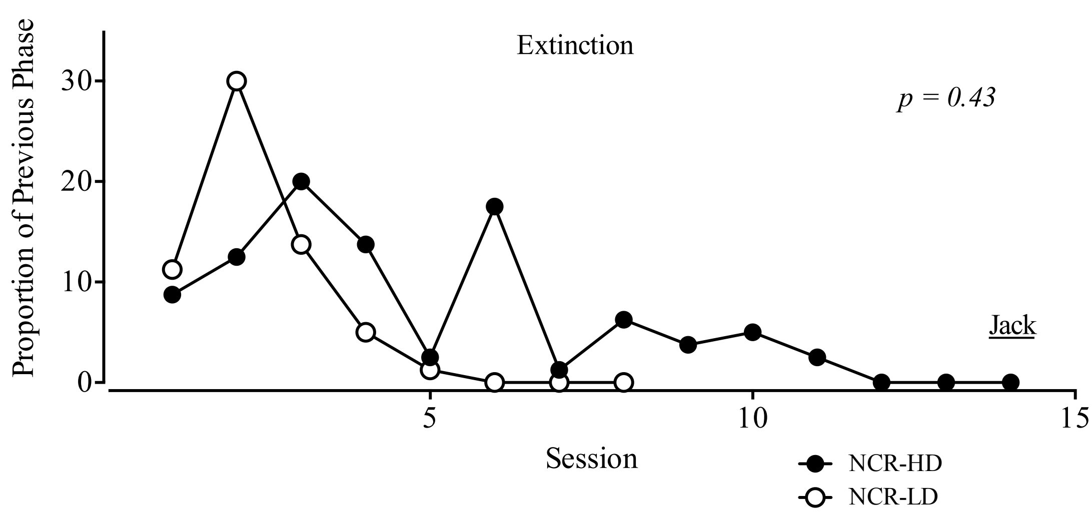

Figure 25. Responding During EXT only for Jack (Proportion of Prior NCR Phase).

Discussion

In this study, we evaluated a refinement to NCR that was designed to increase contingency discriminability and produce faster reductions in the target response when contingent reinforcement ceased (EXT) and was replaced by an NCR schedule that produced the same rate of reinforcement as occurred in baseline (i.e., a switch from a VI 30-s to a VT 30-s schedule). Typically, a switch from a VI to an equivalent VT schedule has been considered a relatively indiscriminate contingency change (Nevin & Shahan, 2011). However, for three of four participants, we observed faster or more immediate reductions in responding when we increased the discriminability of the schedule change by signaling time-based reinforcer deliveries using a different colored reinforcer than the one that we delivered on the response-contingent schedule during the multiple-schedule baseline. These results suggest that for some participants, the reductive effects of NCR might be enhanced by signaling response-independent reinforcers, consistent with the results obtained by Podlesnik and Fleet (2014). The current results extend those of Podlesnik and Fleet by showing similar results with a clinical population (i.e., children with autism) and by implementing a discriminability enhancement that could be practically implemented during NCR. These results also appears to be consistent with Shahan and Sweeney's (2011) model of resurgence, which suggests that persistence in responding may, in part, be a function of the level of distinctiveness between the baseline and NCR conditions.

Nevin et al. (2001) suggested that the relation between contingency discriminability and response persistence can be viewed in the context of generalization decrement, in that response persistence increases and decreases as test stimuli become more and less similar to the training stimulus, respectively. For example, if color wavelength is the relevant variable along which the training stimulus and test stimuli vary during a generalization test, then: (a) those stimuli with highly similar wavelengths to the training stimulus are likely to engender more response persistence during EXT; and (b) those test stimuli with progressively less similar wavelengths are likely to engender progressively less persistence during EXT (for example, see the upper panel of

Figure 8 in Nevin et al.). Our results are consistent with this generalization-decrement hypothesis in that we decreased the discriminative (functional) properties of the time-based reinforcer deliveries by altering their color (e.g., red M&Ms) relative to the reinforcers we delivered contingently during baseline (e.g., green M&Ms). That is, the identically colored reinforcers (e.g., green during baseline and during NCR) exerted more generalized discriminative control and thereby increased response persistence during NCR-LD, whereas the dissimilar colored reinforcers (e.g., green during baseline, red during NCR) exerted less generalized discriminative control and thereby decreased response persistence during NCR-HD for three of the four participants.

It is unclear why we did not see similar differences in response persistence during the two NCR conditions with Jack. One possible explanation for the discrepant results obtained with Jack is that his responding rapidly decreased to low levels in both NCR conditions, and thus the vast majority of the time-based reinforcer deliveries in both NCR conditions occurred in the absence of target responses for Jack. Thus, Jack may have readily discriminated the change from contingent to response-independent reinforcer deliveries without the aid of the different colored reinforcer that we presented only during NCR-HD.

A secondary purpose of this study was to determine whether greater or lesser resurgence would occur when we introduced the EXT-only condition following each of the NCR phases. According to Shahan and Sweeney's (2011) BMT model of resurgence, higher levels of discriminability between the baseline and NCR phases should produce lower resurgence during an EXT challenge following NCR. Just one participant, Alex, displayed responding that was at least somewhat consistent with this prediction. That is, he showed slightly lower levels of proportional responding and reached the termination criterion earlier in the NCR-HD condition relative to the NCR-LD condition. Jack displayed roughly equal levels of response persistence during the EXT-only phases that followed NCR-HD and NCR-LD and responding reached the termination criterion earlier in the low discriminability condition (NCR-LD). In addition, Gen and

Kevin showed greater response persistence during the EXT-only phase that followed NCR-HD relative to the EXT-only phase that followed NCR-LD, both in terms of proportional response rates and in terms of reaching the termination criterion.

Although Shahan and Sweeney's (2011) model of resurgence predicts that higher levels of discriminability between the baseline and NCR phases should produce lower resurgence during an EXT challenge following NCR, the opposite effect is also a possibility. That is, the removal of highly discriminable reinforcer deliveries during a period of EXT following NCR could render the stimulus context more similar to the baseline context than to the NCR context, which could increase target responding through the process of operant renewal (Nakajima, Tanaka, Urushihara, & Imada, 2000). Thus, greater persistence or recurrence of responding following NCR-HD for Gen and Kevin (and to a lesser degree Jack) may be more consistent with the process of operant renewal.

Renewal of operant responding typically occurs in a three-phase sequence. In the first phase, the target response produces reinforcement in one context (e.g., Context A); in the second phase, EXT is implemented in a different context (e.g., Context B); and finally, in the third phase, EXT is implemented either in the first context (e.g., Context A; called ABA renewal) or in a novel context (e.g., Context C; called ABC renewal; Bouton, Todd, Vurbic, & Winterbauer, 2011; Kelley, Liddon, Ribeiro, Greif, & Podlesnik, 2015; Podlesnik & Shahan, 2010). Adapting the ABA renewal model to a NCR-HD intervention relative to the baseline context might be posed thusly. During the first phase, green M&Ms are delivered contingent on responding in Context A. During the second phase, red M&Ms are delivered on a time-based schedule, and the change in the color of the reinforcers alters Context A enough to create a new context (i.e., Context B). During the third phase, all reinforcement deliveries cease and Context B reverts to Context A, thereby completing an ABA renewal sequence.

In the present study, during NCR-HD, it is possible that the delivery of time-based reinforcers of a different color changed the stimulus context sufficiently so that it functioned as a novel stimulus context (Context B in the ABA renewal sequence). Therefore, when the time-based delivery of the different colored reinforcers ceased, the stimulus context reverted to one associated with baseline (Context A). Moreover, altering the stimulus context during NCR-HD also may have facilitated more rapid reduction in responding because the target response never produced contingent reinforcement in the presence of both the specific variant reinforcer (e.g., red M&Ms) and schedule-correlated stimulus (e.g., green M&M index card; see Mace et al., 2010 for results consistent with this hypothesis).

Kincaid, Lattal, and Spence (2015) conducted a study with pigeons in which they combined resurgence and renewal procedures in a manner similar to our procedures. During their study, they exposed three pigeons to a concurrent-resurgence procedure in which key colors served as contextual stimuli. In the baseline phase, they scheduled reinforcement for pecking two keys on concurrent VI 120-s VI 120-s schedules, each correlated with different key colors (e.g., orange, blue). In the alternative-reinforcement phase, they delivered reinforcement on concurrent DRO 20-s schedules. In addition, they changed one of the key colors during this phase (ABA), while the other key color remained the same as baseline (AAA). In the third phase, all reinforcer deliveries ceased and the experimenters changed the color of the ABA key back to its baseline color, thereby creating an ABA-renewal sequence for one of response keys but not the other. They observed greater resurgence on the ABA renewal key with each pigeon, demonstrating that combining an ABA-renewal sequence with a resurgence-sequence procedure increased recurrent responding, something Kincaid et al. referred to as “super-resurgence.”

Results of the present study are consistent with those of Kincaid et al. (2015) in that the NCR-HD sequence was analogous to the ABA renewal sequence and the NCR-LD -sequence was analogous to the AAA renewal sequence. Recent advances in recurrent behavior have begun aligning mechanisms of renewal and resurgence consistent with the concept of super-resurgence (Podlesnik & Bai, 2015; Sweeney & Shahan, 2015).

An alternative to the renewal hypothesis is that blocking occurred. Blocking is a phenomenon that frequently occurs during associative learning with multiple conditional stimuli. Blocking occurs when conditioning of one stimulus (CS1) “blocks” later conditioning of another stimulus (CS2) when the two conditional stimuli (CS1 + CS2) are presented together immediately before the unconditional stimulus (Acebes, Solar, Carnero, & Loy, 2009; Kamin, 1969; Mitchell, Lovibond, Minard, & Lavis, 2006). We observed greater response persistence when EXT only followed NCR-HD, which may have been due to an effect similar to blocking. That is, the delivery of the colored reinforcer formerly associated with NCR in the presence of the RDC may have blocked the stimulus control effects during NCR. However, when we removed the colored reinforcer associated with NCR during EXT, its blocking effects also vacated the RDC context and the stimulus-control effects of the RDC stimulus resumed, which may have led to more prolonged responding. However, this interpretation should be considered tentative and further research into this phenomenon is certainly warranted.

Alex’s results differed from the results obtained with the other 3 participants in that his responding persisted for more sessions during EXT following NCR-LD relative to NCR-HD. This contrary finding may have been due to faulty or ineffective stimulus control of programmed stimuli across conditions. Although we observed discriminated responding during the final five sessions of each baseline phase, Alex engaged in very high rates of responding across the multiple-schedule baseline components, which may have been due to insufficient contact with contingences across components. Alex continued to respond at moderate to high rates during the RIC even during the final sessions of baseline. Furthermore, unlike Gen and Kevin, Alex engaged in similar rates of responding toward the end of each NCR phase, suggesting that our programmed changes in discriminability had only a transitory effect on responding (i.e., we observed a difference between discriminability conditions only during the initial introduction of NCR; see Figure 16).

One limitation of the present study is that it is unknown whether reductions in responding during NCR-HD could have occurred with a novel stimulus that was not previously associated with NCR. That is, it is possible that we could have produced comparable effects simply by delivering a novel reinforcer of a different color during NCR, one that had no prior history of response-independent delivery. Future researchers should compare the effects of a novel reinforcer of a different color during NCR versus a different colored reinforcer with a history of response-independent delivery.

Enhancing discriminability of NCR may have important implications for treatment interventions for destructive behavior in individuals with intellectual disabilities. Namely, the results of the present study suggest that NCR might be improved if the change from contingent reinforcement to NCR is signaled through the delivery of a reinforcer with a different visual appearance than the one delivered during baseline. However, this approach may also increase the probability of recurrence of destructive behavior if the individual is exposed to an extended period of EXT following initiation of NCR with this discriminability manipulation, due to operant renewal. Therefore, researchers should consider methods to mitigate resurgence and/or renewal effects that may occur when NCR is signaled or delivered in an alternative context and subsequently removed when the original baseline context is reintroduced.

CHAPTER 2: NONCONTINGENT REINFORCEMENT AND EXTINCTION

Introduction

The outcomes produced by NCR have been overwhelmingly positive; however, the manner in which NCR is typically executed has differed based on whether destructive behavior is maintained by social or sensory consequences. When destructive behavior is reinforced by social consequences, the reinforcer found to maintain destructive behavior can be withheld following occurrences of the behavior (i.e., EXT of destructive behavior) and delivered on a time-based schedule independent of the individual's behavior (i.e., NCR with EXT; Vollmer et al., 1993). For example, if a functional analysis has determined that adult attention serves as a reinforcer for an individual's disruptive behavior, attention can be withheld following disruptive behavior and delivered on a time-based schedule (e.g., every 2 min).

In contrast, when destructive behavior is maintained by sensory consequences (i.e., automatic reinforcement), NCR typically involves the delivery of a reinforcer other than the one maintaining destructive behavior (e.g., Hagopian & Toole, 2009; Jennet, Jann, & Hagopian, 2011). These reinforcers are often selected based on a preference assessment (Vollmer, Marcus, & LeBlanc, 1994) or a competing stimulus assessment, which involves assessing NCR stimuli based on the extent to which destructive behavior is reduced when those items are made freely available (Piazza et al., 1998; Roscoe et al., 1998; Shore, Iwata, DeLeon, Kahng, & Smith, 1997). For example, if a child engages in self-injurious behavior maintained by automatic reinforcement, NCR may involve the caregiver delivering an iPad® for 2 min out of every 10 min of the child's unstructured free time. Noncontingent reinforcement is often conducted in this alternative manner because when destructive behavior is maintained by automatic reinforcement, the putative reinforcer can be difficult to identify, withhold, or deliver on a response-independent basis (Rapp & Vollmer, 2005; Vollmer, 1994). As such, NCR is typically implemented without EXT because the putative reinforcer remains concurrently available and can be accessed by engaging in destructive behavior (e.g., the child can engage with the iPad® yet continue to engage in self-injury).

Although the results of a number of studies have shown that NCR without EXT can decrease destructive behavior maintained by automatic reinforcement (as well as socially maintained destructive behavior when NCR schedules are dense; Fisher et al., 1999; Hagopian et al., 2000; Wallace et al., 2012), theoretical and empirical findings from BMT suggest that the typical manner in which NCR is implemented for destructive behavior maintained by automatic reinforcement may inadvertently promote persistence of destructive behavior and increase the likelihood of treatment relapse, thereby prolonging the treatment process (Ahearn et al., 2003; Nevin & Shahan, 2011; Sweeney et al., 2014). Behavioral momentum theory proposes that although operant response rate depends on response-reinforcer contingencies, resistance to change, or persistence of destructive behavior, is primarily a function of the contingency between a discriminative stimulus and reinforcement obtained in the presence of that discriminative stimulus (stimulus-reinforcer pairings or Pavlovian contingencies; Nevin & Grace, 2000). Thus, when NCR is superimposed over a pre-existing schedule of automatic reinforcement, the total amount of reinforcement in the treatment context increases, thereby potentially increasing the persistence of the target response.

Both basic and applied experimental research on BMT suggests that behavior may become more persistent when time-based schedules of reinforcement are introduced concurrently with response-dependent reinforcement schedules (Dube et al., 2009; Grimes & Shull, 2001; Mace et al., 1990; Nevin et al., 1990), as is commonly done when NCR is implemented for destructive behavior maintained by automatic reinforcement. According to BMT, delivering a reinforcer on a time-based schedule (i.e., NCR) concurrently with response-dependent reinforcers weakens the relation between target responding and reinforcers, but could strengthen the stimulus-reinforcer relation in the given environmental context (Mace et al., 1990; Nevin et al., 1990). As a result, response rate decreases but behavioral persistence increases in the presence of a disruptor such as operant EXT, which is evidenced by an increase in responding or more extended responding during EXT (Nevin et al., 1983; Pritchard et al., 2014). Therefore, implementing NCR without EXT might be problematic because the stimulus-reinforcer relation is greater than when NCR is implemented with EXT, thereby promoting persistent behavior (i.e., in a given context, the individual has access to both the reinforcer maintaining destructive behavior and the NCR stimulus).

Ahearn and colleagues (2003) evaluated the persistence of stereotypic behavior following periods with and without access to competing stimuli delivered on a VT schedule for three children who engaged in stereotypy maintained by automatic reinforcement. Results suggested that stereotypy was more resistant to a disrupter (i.e., continuous access to a different preferred stimulus) after the researchers exposed the participants to the competing stimulus on a VT schedule relative to the control condition in which the competing stimulus was absent. These results provide credence for a momentum account of behavioral persistence of automatically reinforced responses treated with NCR. Specifically, time-based reinforcer delivery might lower responding when the NCR stimulus is present but increase the persistence of destructive behavior during periods of disruption, such as an EXT challenge in which the NCR stimulus is removed.

Shahan and Sweeney's (2011) model predicts that the removal of alternative reinforcement (e.g., NCR) during EXT eliminates the immediate reductive effect of the intervention, but the effects of repeatedly pairing the stimulus context with increased reinforcer deliveries (i.e., the respondent relation) may continue to affect the persistence of the target response (Nevin & Shahan, 2011). That is, when EXT is introduced, behavior resurges as a result of this historical relation. Therefore, the model predicts that treatment relapse in the form of resurgence is likely to occur when NCR is withdrawn or temporarily suspended, a treatment integrity failure that may occur in more typical environments (e.g., a caregiver of a child with severe aggression may be unable to deliver attention on the prescribed NCR schedule because the caregiver is attending to a sick sibling). Moreover, the model predicts that resurgence will be greater when NCR is implemented without EXT, because the number of stimulus-reinforcer pairings is greater than when NCR is combined with EXT.

Recently, Sweeney et al. (2014) used a multiple-schedule disruptor paradigm to test an analog model of the effects of sensory reinforcers on behavioral persistence following the delivery of alternative reinforcement via NCR with pigeons and children with intellectual disability as participants. With both groups of participants, the authors found that providing alternative reinforcement on a time-based schedule concurrently with programmed analog sensory reinforcers resulted in greater behavioral persistence and resurgence of target responding during an EXT challenge relative to the delivery of analog sensory reinforcers without alternative reinforcement. These results provide an interesting experimental analogue for the treatment of automatically reinforced problem behavior and suggest that implementing NCR for such responses may increase the probability of treatment relapse when these responses encounter a disrupter, such as poor treatment fidelity in the natural environment.

The purpose of the present study was to expand on previous findings by developing an analogue arrangement that tested the predictions of BMT when we implemented NCR with or without EXT. In this study, we evaluated (a) the reductive effects of NCR on target responding when implemented with and without EXT and (b) response resurgence during an EXT challenge in which we terminated all reinforcement deliveries (i.e., both response-dependent and response-independent reinforcers).

Method

Participants and Settings

Three children with a diagnosis of autism spectrum disorder participated. Gen from Experiment 1 also participated in the present study. Gavin, a 5-year-old boy, communicated using two- to three-word vocal requests for preferred items. Jakob, a 6-year-old boy, communicated using three- to five-word vocal utterances. All participants completed all or most activities of daily living independently.

We conducted Gen's sessions in a therapy room at an outpatient clinic of a university-based autism center. Therapy rooms contained a table, two chairs, a laptop computer, and the response materials. We conducted Gavin and Jakob's sessions in living spaces in their respective homes. Rooms contained a table, two chairs, a laptop computer, the response materials, and occasionally other unrelated items (e.g., bed, lamp, clothing). We placed the unrelated items aside at the beginning of each session, and these items did not interfere with experimental sessions.

We selected a preferred item for each participant based on an individualized paired-stimulus preference assessment (Fisher et al., 1992) conducted at the onset of the study. We selected items for inclusion in the preference assessment based on caregiver or therapist report of preferences.

Apparatus

For Gen and Gavin, we used the button-press apparatus and task as described in Experiment 1. For Jakob, we used the adapted chips-in-box apparatus and task as described in Experiment 1. We positioned a 10.2-cm by 5.1-cm index card in clear sight, next to each participant's respective apparatus. For Gavin and Jakob, each side of the card was of a different color, which served to indicate which component of a multiple schedule was in effect (i.e., the schedule-correlated stimulus). The experimenter sat across from the participant and rotated the card manually. For Gen, the index card showed only an image of the reinforcer. The therapist blocked all participant attempts to touch or manipulate the index card.

Response Measurement, Data Analysis, and Interobserver Agreement

Responses were defined and measured in a manner identical to that described in Experiment 1. Similarly, to account for differences in baseline response rates across phases for Gen and between components for Gavin and Jakob, we compared levels of responding during the NCR conditions and levels of resurgence during the EXT only phases expressed as a proportion of baseline, in a manner identical to Experiment 1. Last, to further analyze potential differences in levels of resurgence during the EXT only phases, we conducted Fisher's (1935) randomization test across phases with Gen and across components for Gavin and Jakob during the first five EXT-only sessions (identical to Experiment 1). Additionally, we conducted the sign test for matched pairs (Hays, 1963) for Gen and Gavin. Because Fisher's (1935) test does not take into account changes in behavioral trend as target responding is exposed to EXT, it may incorrectly produce statistically insignificant results despite greater resurgence being observed in one condition versus another.

An independent second observer collected data simultaneously with the primary data collector on 39% of Jakob's sessions. We calculated interobserver agreement by dividing the smaller obtained value by the larger obtained value for each session. Each quotient was then converted to a percentage. Interobserver agreement averaged 99% (range, 99% to 100%) for depositing poker chips into the box and 100% for number of reinforcers earned.

Experimental Design

We used a hierarchical reversal design to evaluate the effects of response persistence during NCR and response resurgence during EXT with Gen. That is, the two primary phases, NCR with EXT and NCR without EXT, each had three sub phases, baseline, treatment, and EXT. Each session lasted 5 min.

For Gavin and Jakob, we used a multiple-schedule design with three phases: baseline, treatment, and EXT. Sessions lasted 10 min and included two components, NCR with EXT and NCR without EXT. Each component lasted 1 min. We presented each component 5 times in a quasi-random order during each session and signaled each component with the index card described previously. As a result, we exposed Gavin and Jakob to each condition for 5 min.

Procedure

At the start of each session, the experimenter told the participant "Here is the task, you can do as much or as little as you want." For Gen and Gavin, the preference assessment identified a tangible item as highly preferred. Therefore, during the experimental sessions, we removed the response apparatus and index card, and paused the session clock 15 s to allow these participants to consume the reinforcer. For Jakob, the preference assessment identified an edible item as highly preferred, and we did not pause the session clock because reinforcer consumption time was negligible and did not interfere or compete with interacting with the response apparatus.

Pretraining (not displayed). We conducted pretraining to teach participants how to interact with the response apparatus in a manner identical to Experiment 1. For Gen, we also conducted pretraining following each EXT-only phase and prior to each baseline phase to mitigate potential sequence effects that may have occurred as a result of previous exposure to EXT. We did not present the index cards (that we later used as discriminative stimuli) during the pretraining sessions.

Baseline. We delivered reinforcement on a VI 30-s schedule. For Gavin and Jakob, the experimenter rotated the index card according to the multiple schedule, but an independent VI 30-s schedule operated in each component during baseline.

NCR with EXT. During this condition, responding did not produce the reinforcer. Instead, we delivered the reinforcer on a VT 30-s schedule. To enhance the effectiveness of NCR in this phase, a 4-s DRO procedure was added to the end of the VT schedule, thus delaying delivery of the reinforcer if the participant emitted the target response within 4 s of the scheduled reinforcer delivery. We included this brief DRO contingency to preclude temporal contiguities between the response and reinforcer.

NCR without EXT. In this condition, the target response continued to produce reinforcement on a VI 30-s schedule. In addition, we also delivered reinforcers on an independent VT 30-s schedule. Therefore, we superimposed the NCR schedule on the baseline schedule of reinforcement. As such, the programmed rate of reinforcement in this context was twice as much as the comparative NCR with EXT condition. This condition was analogous to how NCR is typically implemented for destructive behaviors maintained by sensory consequences.

EXT Only. Following the NCR conditions, we introduced a phase of EXT. During this phase, we terminated all programmed reinforcer deliveries. The purpose of this phase was to evaluate whether prior exposure to NCR with or without EXT produced differential outcomes with respect to response resurgence when all reinforcement was withdrawn. For Gavin and Jakob, although the experimenter rotated the index card according to the multiple schedule, EXT was in place during both components. We designed this EXT challenge to be analogous to situations in which caregivers may fail to implement NCR according to the prescribed schedule.

For the present analysis, we defined resurgence as responding that occurred at a rate exceeding the average level observed during the prior three sessions of the NCR phase in at least one of the first five sessions of the EXT only phase. This definition is more conservative than the one used by Volkert and colleagues (2009) to define resurgence following FCT.

Results

For Gen, we used the same preferred toy horses as reinforcers that were used in Experiment 1 (see Figure 2). For Gavin, the preference assessment identified an iPad as highly preferred (Figure 26). For Jakob the preference assessment identified grape juice as highly preferred (Figure 27).

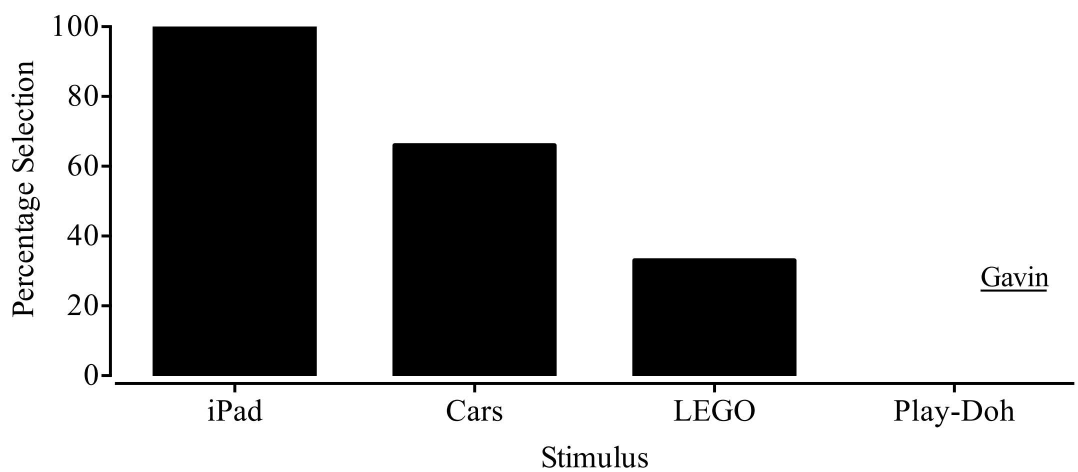

Figure 26. Preference Assessment Results for Gavin.

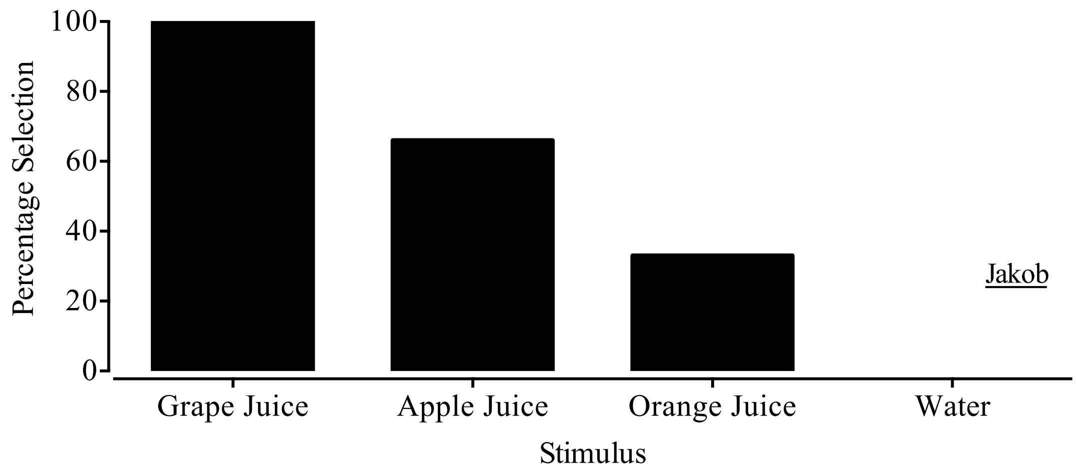

Figure 27. Preference Assessment Results for Jakob.

Figure 28 displays the rates of responding during baseline, the two NCR conditions, and the EXT-only phase for Gen. Gen engaged in high, stable levels of button pressing during the initial baseline phase (*M* = 780 RPH during the last five sessions; range, 660 to 900). She displayed similar rates of responding during the three subsequent baseline phases. When we introduced NCR with EXT, responding slowly but steadily decreased to near-zero levels. Gen displayed a similar pattern of response deceleration during the subsequent implementation of NCR with EXT. In contrast, during both NCR-without-EXT phases, responding decreased much more immediately (relative to NCR with EXT), but never reached or approached near-zero levels. The EXT-only phases that followed NCR without EXT showed higher levels of responding than the EXT-only phases that followed NCR with EXT, but the differences were less robust during the second set of EXT-only phases. In addition, the two EXT-only phases that followed NCR without EXT met our criterion for resurgence whereas the two EXT-only phases that followed NCR with EXT did not.

Figure 29 displays the obtained rates of reinforcement during baseline, the two NCR conditions, and the EXT-only phase for Gen. Across NCR phases, Gen obtained approximately 1.75 times more reinforcers during the NCR without EXT conditions (*M* = 183 reinforcers per hour; range, 96 to 240) relative to the NCR with EXT conditions (*M* = 104 reinforcers per hour; range, 72 to 120).

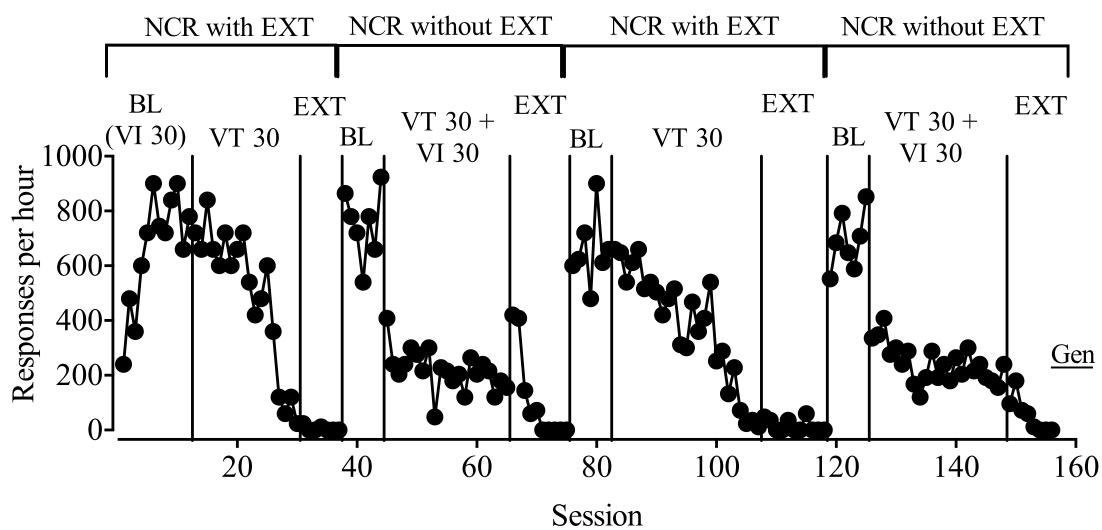

Figure 28. Primary Results of NCR comparison with Gen.

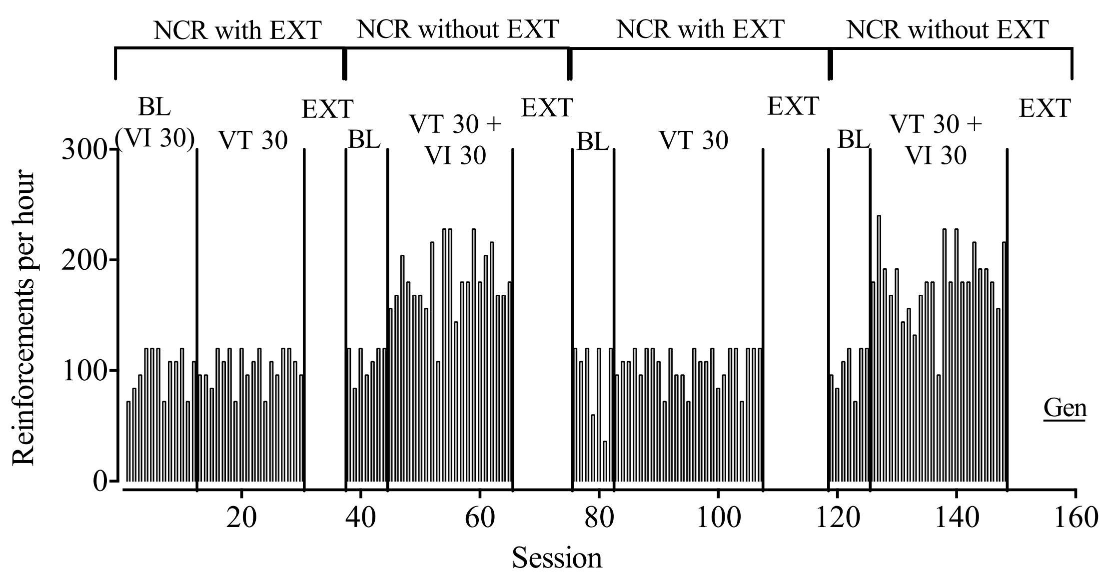

Figure 29. Obtained rate of reinforcement across NCR comparison with Gen.

Gavin (Figure 30) engaged in stable and near-equal levels of button pressing across the two multiple-schedule components during baseline. Similarly, Gavin obtained a near-equal number of reinforcers in both components during baseline (Figure 31). During the NCR comparison phase, responding decreased in both the NCR-with-EXT (*M* = 735 RPH; range, 480 to 1008) and NCR-without-EXT conditions (*M* = 423 RPH; range, 288 to 876); however, NCR without EXT produced the greater response decrement. Gavin obtained nearly twice as many reinforcers during the NCR without EXT component (*M* = 234 reinforcers per hour; range, 216 to 240) relative to the NCR with EXT component (*M* = 118 reinforcers per hour; range, 108 to 120). Finally, the EXT-only phase in the stimulus context associated with NCR without EXT showed higher levels of responding and greater resurgence than the EXT-only phase in the stimulus context associated with NCR with EXT.

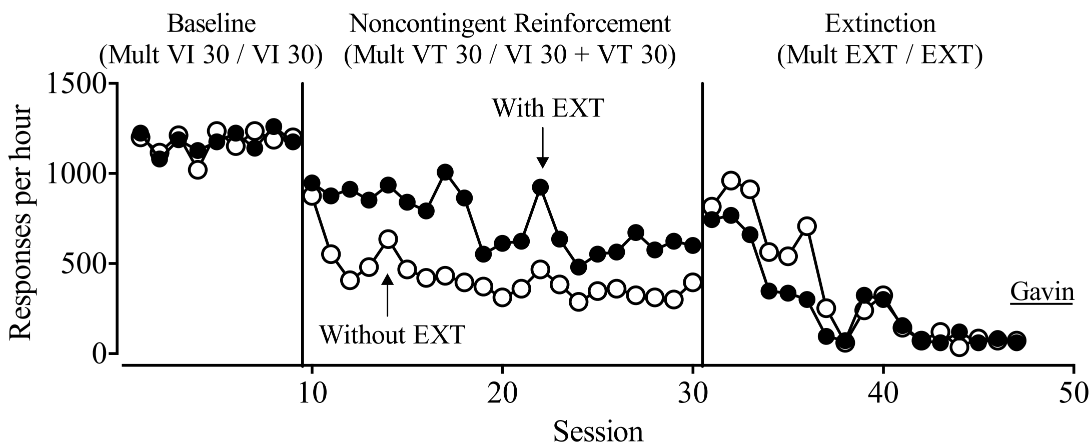

Figure 30. Primary Results of NCR comparison with Gavin.

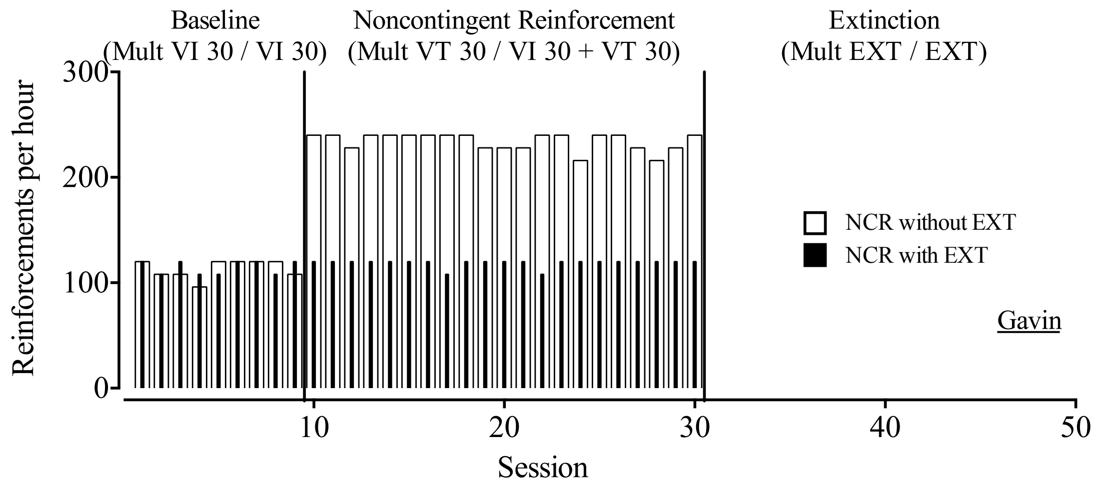

Figure 31. Obtained rate of reinforcement across NCR comparison with Gavin.

Jakob initially engaged in high and variable levels of button pressing during the multiple-schedule baseline (Figure 32). However, Jakob was engaging in near-equal and stable levels of responding in both components during the final five sessions of baseline. In addition, Jakob obtained a near-equal number of reinforcers in both components during baseline (Figure 33). When we introduced the two NCR conditions, responding immediately decreased to low levels in both conditions (*Ms* = 69 and 64 RPH during NCR with EXT and NCR without EXT, respectively), and Jakob obtained only slightly more reinforcers in the NCR without EXT component (*M* = 166 reinforcers per hour; range, 120 to 240) relative to the NCR with EXT component (*M* = 120 reinforcers per hour). During the EXT-only phase, Jakob displayed resurgence in both components and slightly higher responding in the component associated with NCR without EXT.

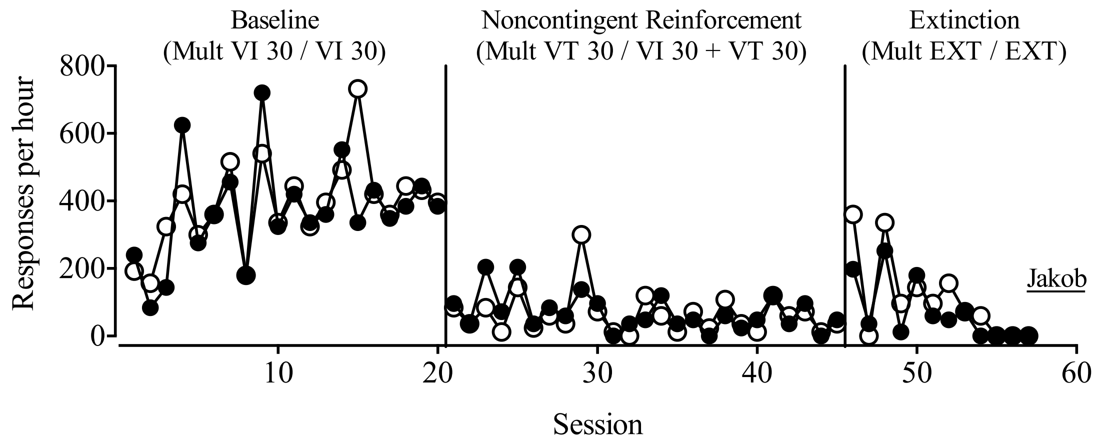

Figure 32. Primary Results of NCR comparison with Jakob.

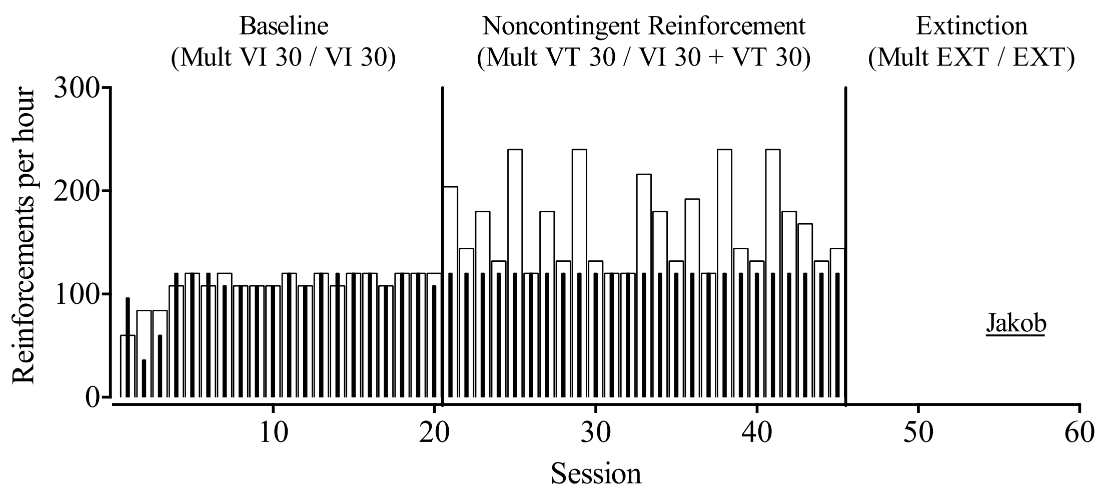

Figure 33. Obtained rate of reinforcement across NCR comparison with Jakob.

Figures 34 and 35 display levels of responding across NCR conditions and EXT-only phases expressed as a proportion of baseline for Gen (Figure 34) and Gavin (Figure 35). Consistent with the absolute rates of responding, Gen and Gavin showed more immediate reductions in proportional responding during NCR without EXT relative to NCR with EXT. In addition, for both of these participants, we observed greater resurgence when EXT only followed

NCR without EXT (*p*s < 0.01 and = 0.09, respectively for Fisher's randomization test; *p*s < .01 and < .02, respectively for the sign test with matched pairs).

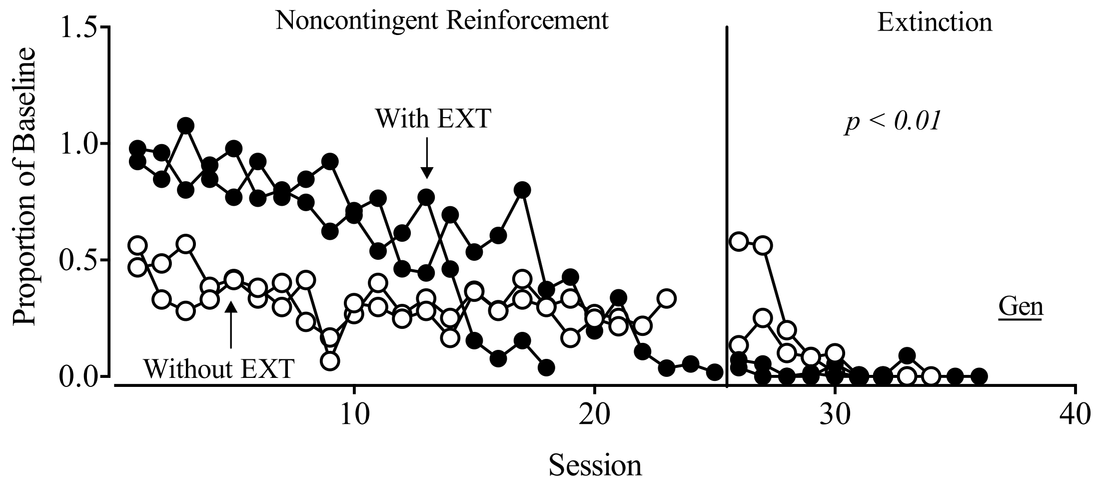

Figure 34. Responding During NCR and EXT only for Gen (Proportion of Baseline).

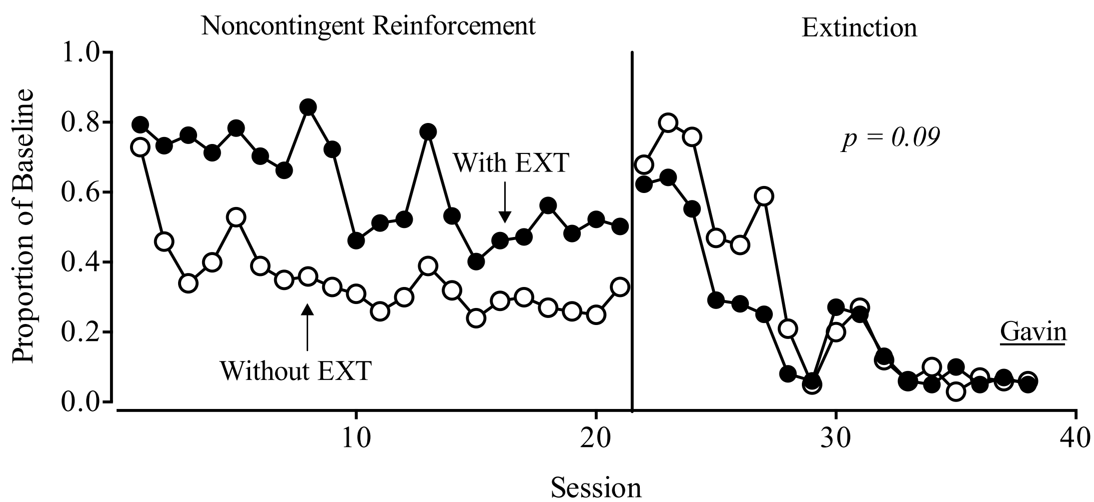

Figure 35. Responding During NCR and EXT only for Gavin (Proportion of Baseline).

For Jakob (Figure 36), the proportional rates of responding did not reveal any significant differences between NCR with and without EXT during the treatment phase and during the subsequent EXT-only phase ($p = .29$). For all participants, NCR whether implemented with or without EXT lead to reductions in target responding relative to baseline, analogous to treatment effects typically observed when NCR is implemented as treatment for destructive behavior.

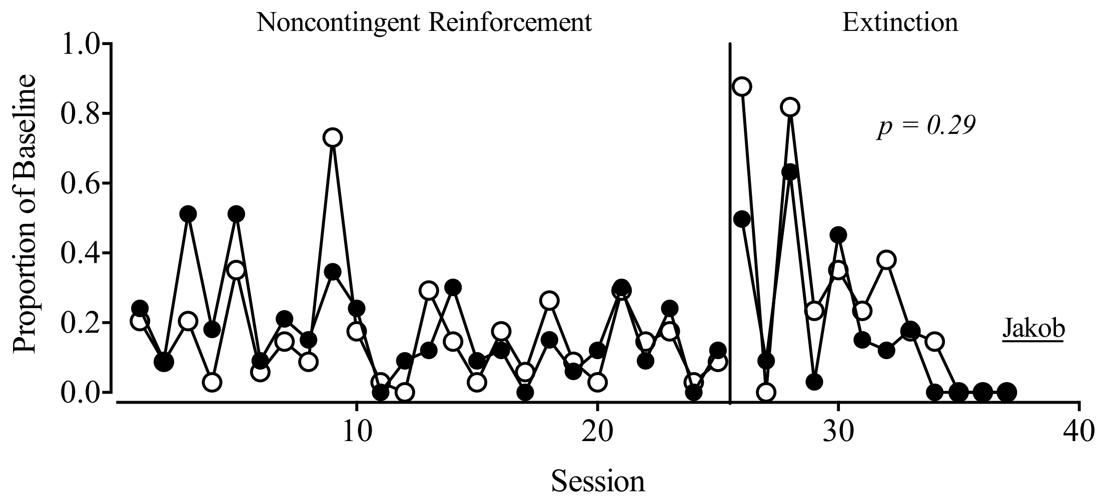

Figure 36. Responding During NCR and EXT only for Jakob (Proportion of Baseline).

Discussion

In this study, we compared the effects of NCR when implemented with EXT (as is commonly done for destructive behavior maintained by social consequences) and without EXT (as is commonly done for destructive behavior maintained by automatic reinforcement), as well as how prior exposure to these different NCR arrangements affected levels of response resurgence when we terminated reinforcer deliveries. For two of three participants (Gen and Gavin), we observed more immediate reductions in target responding when we implemented NCR without EXT relative to NCR with EXT. However, for Gen, only NCR with EXT decreased responding to near-zero levels, whereas neither condition produced near-zero levels of responding for Gavin. Further, for Gen and Gavin, we observed greater resurgence when EXT was introduced following NCR without EXT. For one participant (Jakob), we observed no significant differences between the two NCR arrangements, neither during the treatment phase nor during the subsequent EXT-only phase.

The obtained results for Gen and Gavin are consistent with the predictions of BMT about response persistence and resurgence using the model of resurgence proposed by Shahan and Sweeney (2011). That is, the response-independent delivery of alternative reinforcers lowered the rate of responding by weakening the operant (or response-reinforcer) contingency. However, providing alternative, response-independent reinforcers concurrently with response-dependent reinforcers increased the target response's persistence during EXT only presumably by increasing stimulus-reinforcer pairings (i.e., respondent contingency effects). In addition, the disruptive effects of terminating the contingency between the target response and reinforcer deliveries began sooner for NCR with EXT relative to NCR without EXT (i.e., operant EXT of the target response began in the treatment and EXT-only phases, respectively). Therefore, when we introduced EXT only, responding may have been less persistent due to the duration of exposure to EXT during NCR with EXT relative to NCR without EXT. Behavioral momentum theory predicts that longer exposures to EXT tend to produce less resurgence (see Wacker et al., 2011 for results consistent with this prediction).

Gen showed less robust resurgence during the second implementation of EXT only following NCR without EXT, which was the fourth exposure to EXT only overall. Wacker et al. (2011) repeatedly exposed an FCR to extended EXT-test phases and observed progressively lower levels of resurgence of destructive behavior in each successive EXT phase. Both the Wacker et al. results and the current results obtained for Gen are consistent with the predictions of BMT. Taken together, these results suggest that decrements in resurgence across multiple EXT-only conditions can occur regardless of whether reinforcers are delivered on a response-independent basis (as is commonly done during NCR) or dependent on an alternative appropriate response (as is commonly done during FCT). These findings are consistent with those of Sweeney et al. (2014) and of BMT more broadly (Nevin et al., 1990).

Interestingly, during the NCR phases for Gen and Gavin, we observed more immediate reductions in responding in the NCR without EXT condition relative to NCR with EXT.

However, over time Gen's responding reduced to near-zero levels in NCR with EXT but not in NCR without EXT. In contrast, Gavin showed consistently lower levels of responding in NCR without EXT throughout the treatment phase, but responding persisted throughout the treatment phase, never approaching near-zero levels in either condition. Gavin's response pattern differs from those obtained by Borrero, Bartels-Meints, Sy, and Francisco (2011), who found that concurrent fixed-interval (FI) and fixed-time (FT) reinforcement schedules maintained responding at levels similar to those produced by the FI schedule alone in two of three adult participants with schizophrenia. The differences obtained from the present study and for those two participants from Borrero et al. may be partially due to differences in schedule requirements. That is, while Borrero and colleagues used FI 60-s and FT 60-s schedules, we used denser and more variable VI 30-s and VT-30 s schedules. In addition, the greater reductions observed with two of our participants during NCR without EXT may have been partially due to the fact that we programmed a brief DRO contingency at the end of each VT reinforcement interval, whereas Borrero et al. did not. Brief DRO contingencies (also called change-over delays) are designed to help prevent adventitious reinforcement resulting from contiguous pairings of responding followed by time-based reinforcer deliveries.

Hagopian et al. (2000) evaluated the effects of NCR with and without EXT on destructive behavior for four participants with intellectual disabilities. They found that dense schedules of NCR without EXT all but eliminated destructive behavior and hypothesized that one mechanism responsible for behavior change was reinforcer satiation. Similarly, Wallace et al. (2012) argued that dense NCR schedules are likely effective by altering the motivating operation for the reinforcer. In the present study, we implemented NCR on a schedule that matched the baseline response-dependent reinforcement schedule in both the NCR conditions. It is possible that in the NCR without EXT condition, the relative value of the reinforcer decreased because we delivered more reinforcers during NCR without EXT (i.e., on both response-dependent and response-independent schedules). Because the overall rate of reinforcement was lower in the NCR with

EXT condition, the EO for the reinforcer probably remained higher relative to the NCR without EXT condition and subsequently produced more responding, despite the fact that the response-reinforcer dependency was eliminated. However, the decreasing trend during the NCR with EXT phases for Gen suggest that both satiation and EXT likely operated on target responding during terminal NCR sessions.

An alternative interpretation, and one that may be more consistent with Shahan and Sweeney's (2011) resurgence model, is that the transition from baseline to NCR without EXT provided a more salient change in stimulus conditions than the transition from baseline to NCR with EXT. That is, when we implemented NCR with EXT, no salient stimulus change occurred that signaled to the participants that the contingency had changed from a response-dependent VI-30 s schedule to a response-independent VT-30 s schedule. In contrast, during NCR without EXT, the additional reinforcers delivered on the VT schedule may have served a discriminative function, thereby signaling the schedule change. Ringdahl, Vollmer, Borrero, and Connell (2001) found that when they yoked FT-reinforcement schedules to baseline FI-reinforcement schedules (i.e., similar rates of reinforcement), responding persisted more so than when they introduced more disparate or dissimilar FT schedules following an FI baseline. In the present study, NCR without EXT differed from the VI baseline more so than NCR with EXT, which maintained approximately the same rate of reinforcement. Future research should be directed toward evaluating how the discriminability or saliency of contingency changes from response-dependent to response-independent schedules influences whether the target response decreases rapidly or persists for an extended period of time.

Whereas Gen and Gavin showed response patterns consistent with BMT, Jakob did not show differentially lower levels of responding during NCR without EXT, nor did he show increased resurgence during this condition relative to NCR with EXT. There are at least two possibilities for the discrepant results observed with Jakob. First, Jakob received only marginally more reinforcers in the NCR without EXT condition relative to the NCR with EXT condition (see

Figure 1, third panel, second phase). Of the three participants in the present study, Jakob's obtained rate of reinforcement across NCR conditions was most similar. If, as BMT predicts, resurgence is a product of stimulus-reinforcer pairings, it is possible that the number of such pairings did not differ sufficiently to affect levels of resurgence when EXT only was introduced. Second, given that Jakob engaged in similar levels of responding across NCR components, it is possible that the schedule-correlated stimuli did not produce discriminated responding. This type of stimulus control failure may occur for a number of reasons and has been documented in clinical populations (Saini, Miller, & Fisher, in press). As such, it is possible that insensitivity to the different NCR arrangements resulted from the schedule-correlated stimuli failing to establish discriminative control over responding. That is, it is possible that Jakob discriminated the change from baseline to the two NCR conditions but did not discriminate the schedule differences between the two NCR schedules, perhaps resulting in carry-over effects across components.

Although we obtained results consistent with laboratory and applied studies of BMT for two of three participants, this study was not without limitations. First, we compared NCR with EXT to NCR without EXT because EXT is not commonly programmed for destructive behavior maintained by automatic reinforcement. However, our disruptor test was EXT only, which may not be an ideal disruptor test for behavior maintained by sensory consequences given that the reinforcer maintaining destructive behavior is always available, therefore the participant's behavior contacting conventional EXT is unlikely in both clinical settings and typical environments. A more suitable disruptor for examining persistence of behavior maintained by sensory consequences might be distraction or concurrently available alternative stimuli, as these do commonly occur in typical environments and have both been used to good effort in previous BMT studies (e.g., Ahearn et al., 2003; Mace et al., 1990; Parry-Cruwys et al., 2011). Second, it is commonly argued that for destructive behavior maintained by automatic reinforcement, the sensory reinforcer maintaining destructive behavior cannot be separated from the response itself (Vollmer, 1994; Rapp & Vollmer, 2005). However, in the present study we used the same reinforcer throughout all phases, both during VI delivery and VT delivery. We did this to control for potential differences in preference across reinforcers and to approximate how NCR is implemented with EXT. However, it is highly probable that programmed reinforcers during NCR without EXT would differ qualitatively from the sensory reinforcers maintaining destructive behavior. Third, we used VI and VT schedules as these are the reinforcement schedules most typically used when evaluating behavioral persistence because (a) the number of programmed reinforcers can be better controlled (relative to ratio schedules), and (b) interval schedules are more resistant to EXT than ratio schedules (Nevin, 2012). However, if destructive behavior is maintained by sensory consequences, the reinforcement schedule may more closely approximate a continuous reinforcement schedule (though this supposition remains speculative). Future researchers might consider studying behavioral persistence following other reinforcement schedules (e.g., ratio schedules) that are commonly used in applied settings.

Despite these limitations, the findings of Gen and Gavin's analyses may have important implications for applied practice. Specifically, although implementing NCR without EXT might result in more immediate decreases in responding, resurgence is likely to be greater when the participant's behavior contacts a disruptor such as EXT. Therefore, it may be preferable to implement NCR with EXT whenever possible. One method of implementing NCR for destructive behavior maintained by automatic reinforcement might be to concurrently implement response blocking (e.g., Carr, Dozier, Patel, Adams, & Martin, 2002), which has been demonstrated to function as operant EXT in some circumstances (Smith, Russo, & Le, 1999). Therefore, in some situations, NCR can be implemented while the putative sensory reinforcer can be withheld. Unfortunately, this does not remedy the problem of providing an alternative stimulus, one other than the reinforcer maintaining destructive behavior during NCR. Nevertheless, future researchers might consider this alternative approach to NCR without EXT for destructive behaviors maintained by automatic reinforcement in order to mitigate subsequent response resurgence.

CHAPTER 3: GENERAL DISCUSSION

The overarching theme of the present research was to identify important refinements of NCR, based on BMT and Shahan and Sweeney's (2011) model of resurgence, that when implemented would result in faster suppression of responding during NCR and mitigate response resurgence when NCR was withdrawn. Data presented in Chapters I and II speak to the potential role of contingency discriminability and EXT of target responding, respectively, as such refinements. These refinements may ultimately have implications for the treatment of destructive behavior and provide further insight into the current understanding of NCR.

Research on behavioral persistence and resurgence with clinical populations (i.e., individuals with intellectual and developmental disabilities) has focused primarily on the effects of rate of reinforcement on the persistence of a target behavior in the face of disruptor (e.g., Mace et al., 2010). However, rate of reinforcement is only one parameter, among many, in Shahan and Sweeney's (2011) model of resurgence, and few studies have attempted to examine variables other than rate of reinforcement on behavioral persistence. In Study 1, we evaluated the role of discriminability as a variable that influenced persistent responding during NCR (parameter *d* in the equation) because typical implementation of NCR involves time-based reinforcer deliveries in the absence of any environmental changes that may serve a discriminative function. We hypothesized that increasing discriminability would result in faster suppression of responding when we introduced NCR because the novel reinforcer variant (i.e., a different colored reinforcer) should facilitate discrimination of the change from baseline to NCR. In accordance with the predictions of BMT, three of four participants showed faster decrements in responding when we introduced NCR with a stimulus previously associated with NCR relative to more typical methods of implementing NCR, which involve the delivery the reinforcing stimulus previously associated with contingent reinforcement.

In Experiment 1, we also hypothesized that introducing EXT following NCR with higher discriminability would lower the likelihood of resurgence when NCR was terminated. However, we observed greater resurgence in responding following the condition associated with high-discriminability NCR for three of four participants, contrary to our prediction. This result suggests that although increasing saliency of contingency change between contingent reinforcement and NCR may enhance the effectiveness of NCR, it may also increase the likelihood of resurgence in cases where NCR is terminated or temporarily suspended (e.g., failing to deliver the reinforcer at the prescribed time). It is possible that this untoward effect, which appeared to result from our prior discriminability manipulation, is the result of super-resurgence and the context-renewal phenomena. Future researchers should consider methods of maintaining the positive effects of increasing discriminability of contingency change to NCR, while also mitigating potential super-resurgence effects.

In Study 2, we evaluated parameter *r* in Shahan and Sweeney's (2011) model of resurgence as it relates to NCR implemented with and without EXT. As noted previously, NCR is typically implemented with EXT for destructive behavior maintained by social consequences, but NCR is typically implemented without EXT for destructive behavior maintained by sensory consequences. Based on the model, we hypothesized that additional reinforcers delivered when EXT was not programmed concurrently with NCR would result in greater resurgence when we terminated all reinforcement (both contingent and noncontingent) because these additional reinforcers would increase the overall rate of reinforcement in the NCR context. In accordance with the predictions of BMT, for two of three participants, implementing NCR without EXT resulted in more immediate reductions in responding (operant contingency); however, this condition also produced more resurgence relative to NCR with EXT (respondent [or Pavlovian] contingency). The results of Study 2 suggest that EXT should be implemented concurrently with NCR whenever possible, even for behaviors maintained by automatic reinforcement. Future researchers should consider methods that increase the practicality of implementing EXT for behaviors maintained by automatic reinforcement (e.g., response blocking) and evaluate whether such methods do in fact decrease resurgence.

Translational research, or research that builds on basic research to address issues of social importance, may have profound implications for current practices in applied behavior analysis (Hineline & Rosales-Ruiz, 2013). The results of Study 1 and Study 2, which fall into the realm of translational research, may have significance for how NCR is implemented in practice with individuals who engage in severe destructive behavior. The results of Experiment 1 suggest that introducing NCR should be done with stimuli that are similar to target stimuli but that have been historically paired with NCR. For example, a child who engages in aggression to gain access to an iPad may engage in less aggression if a novel iPad is introduced during NCR (e.g., a blue cased iPad that has historically been delivered in the absence of aggression, on a time-based schedule). However, future applied research may be necessary to determine the degree of discriminability necessary for such stimuli to come to control responding (e.g., a blue cased iPad may be too similar to the iPad used in the child's home environment to facilitate a discriminative effect). The degree of discriminability may thus require further investigation within a parametric analysis to determine the gradient of discriminability change. For example, a contingency change from VI 30 s to VT 300 s is likely to produce larger decrements in responding than a contingency change from VI 30 s to VT 30 s because more drastic changes in the schedule of reinforcement from those occurring in baseline are likely to also enhance discriminability of contingency change (see Ringdahl et al., 2001 for results consistent with this hypothesis).

With respect to Study 2, the implications for practice center on how NCR is implemented for destructive behavior maintained by automatic reinforcement, a particularly challenging form of destructive behavior wherein the specific reinforcer responsible for maintenance can be difficult to identify. In addition to response blocking as a practical method to facilitate an EXT effect for behaviors maintained by automatic reinforcement, the identification of matched stimuli (e.g., Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Rapp, 2007) may allow the behavior analyst to control, to some extent, the sensory reinforcer maintaining destructive behavior. If so, the behavior analyst might implement response blocking plus matched stimuli to mimic NCR with

EXT in a manner more similar to cases of destructive behavior maintained by social consequences. The analogue model used in the current investigation may provide way to evaluate the effects of matched stimuli and response blocking, individually and combined, during treatment and also during periods when the treatment is not implemented as planned. Moreover, this model could be used to compare the effects of matched and unmatched reinforcers on nondangerous target responses in clinical populations. Comparing various treatment alternatives for automatically reinforced destructive behavior in this manner may provide useful clinical information without subjecting participants or caregivers to the risks associated with severe SIB and aggression, respectively.

The results of Study 2 suggest that NCR without EXT produces more immediate reductions in destructive behavior, which might be appealing to behavior analysts in practice when an immediate reduction in severe problem behavior is warranted. However, future researchers should consider methods of maintaining the positive effects of inhibiting response resurgence when NCR with EXT is implemented, while producing immediate reductions in responding similar to when NCR is implemented without EXT. The results of Study 2 suggest that one potential method would be to initially superimpose a dense time-based schedule over an existing contingent reinforcement schedule (in order to produce an immediate reduction in the target response), and then thin the contingent schedule until EXT is in effect (in order to further reduce the response to near-zero levels). As previously mentioned, testing this supposition using the current model (i.e,, using a nondangerous target response with a clinical population) may be prudent before applying such procedures to severe destructive behavior.

We based Studies 1 and 2 on the model of resurgence developed by Shahan and Sweeney (2011), and this model provided a method to refine NCR that could potentially enhance the effectiveness of NCR interventions and subsequently reduce response resurgence. However, Studies 1 and 2 examined only two such refinements within the model, whereas their quantitative model includes a number of parameters that could be manipulated to further refine NCR interventions. For example, enhancing the effectiveness of contingency termination would affect parameter *c* in the equation, which should result in more immediate effects of NCR. Increasing the time of the NCR intervention prior to introducing the EXT disruptor test would affect parameter *t*, which should result in less overall resurgence when NCR is terminated. Manipulations of parameter R_a would change the overall rate of reinforcement during NCR, which could be leveraged to minimize resurgence following NCR interventions. Finally, multiple parameters could be manipulated simultaneously to produce the greatest reductions in responding when NCR is introduced (e.g., combining the reductive effects of parameters *d*, *c*, and *t*). Therefore, future researchers should continue to investigate the other parameters of Shahan and Sweeney's model and continue to use BMT as a guiding metaphor that could enhance and refine our current understanding of the basic processes that influence the effectiveness of NCR.

The extension of BMT to the assessment and treatment of severe behavior disorders remains in its infancy. However, the results of Studies 1 and 2 provide promising preliminary evidence regarding how interventions for destructive behavior, specifically NCR, can be improved by leveraging advancements in the experimental analysis of behavior. Results from translational studies such as those presented in this dissertation also speak to the generality of animal research findings and the relevance of BMT in applied behavior analysis. It is likely that the assessment and treatment of severe destructive behavior will continue to be informed by basic and applied developments in BMT in the foreseeable future.

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