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Relations between quality of reinforcement and the persistence of task completion

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RELATIONS BETWEEN QUALITY OF REINFORCEMENT AND

THE PERSISTENCE OF TASK COMPLETION

by

Patrick William Romani

A thesis submitted in partial fulfillment of the requirements
for the Doctor of Philosophy degree in
Psychological and Quantitative Foundations (School Psychology)
in the Graduate College of The University of Iowa

May 2014

Thesis Supervisors: Professor David P. Wacker
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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

Patrick William Romani

has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Psychological and Quantitative Foundations (School Psychology) at the May 2014 graduation.

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To those who tell me what I need to hear, not what I want to hear. Thank you for pushing me to excel.

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ABSTRACT

Behavioral momentum theory (BMT) provides a theoretical framework for studying the persistence of behavior when challenged. The typical experimental arrangement to study persistence involves reinforcing a behavior according to a multiple schedules design. Unique schedules of reinforcement are programmed to each component. When steady-state responding occurs, the schedules of reinforcement are disrupted by a challenge condition (e.g., extinction, distraction, or prefeeding). The multiple schedules component that maintains the greatest level of responding during disruption is described as being more persistent. Basic research has shown that rate of reinforcement is a reliable predictor of persistence. The multiple schedules component associated with the higher rate of reinforcement persists longer than the multiple schedules component associated with the lower rate of reinforcement during disruption. Applied researchers have recently begun translating BMT to problems of social significance. The success of these initial translations suggests that relations between other dimensions of reinforcement and persistence should be studied. The current two-experiment study investigated the effect of quality of reinforcement on the persistence of task completion. Three participants with a history of engaging in problem behavior to escape from demands participated in Experiment I. After showing the conditions under which participants would and would not allocate away from a work task to engage with a preferred item, a baseline measure of task completion was obtained. Task completion was then reinforced with attention or tangibles within a multiple schedules design. Orange tokens signaled access to tangible reinforcement and yellow tokens signaled access to attention reinforcement. After steady-state responding occurred, preference for attention and tangibles was assessed within a concurrent schedules design. Extinction was then implemented to disrupt task completion within each component of the multiple schedules design. Results showed modest differences in the persistence of task completion with task completion in the multiple schedules component associated with the delivery of the more preferred reinforcer persisting longest. The modest differences in persistence were smaller than what has previously been shown in the literature. Thus, a follow-up experiment was conducted to evaluate the effect of reinforcer potency on the persistence of task completion. Three participants with a history of engaging in problem behavior to escape from demands participated in Experiment II. After identifying relatively more and less preferred stimuli with a multiple stimulus without replacement (MSWO) preference assessment, a unit price analysis was conducted to evaluate the potency of these two items within a concurrent schedules design. Task completion was then reinforced with the more and less potent reinforcers according to a multiple schedules design. After showing steady-state responding, task completion was disrupted by extinction. Results clearly showed greater persistence of task completion under the component associated with the delivery of the more potent reinforcer for two of three participants. Results from both experiments are discussed in terms of their conceptual and applied implications.

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CHAPTER I

INTRODUCTION

A common problem encountered by applied behavior analysts when implementing behavioral treatment programs is the resurgence of problem behavior (Shahan & Sweeney, 2011; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009). Resurgence refers to the reemergence of a response during periods of extinction when reinforcement is no longer delivered contingent on a target behavior (Lattal & Peter-Pipkin, 2009). Researchers have shown that challenges to treatment, such as schedule thinning (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000) or poor treatment integrity (Fryling, Wallace, & Yassine, 2012), may result in the resurgence of problem behavior, which limits the extent to which a treatment can be effective (Nevin & Wacker, 2013; Volkert et al., 2009). The inverse of resurgence is persistence (Shahan & Sweeney, 2011), which refers to the continued occurrence of behavior during challenges to treatment (Nevin, 1974; Nevin, Mandell, & Atak, 1983). The long-term goal of behavioral treatment is the persistence of appropriate behavior with little to no resurgence of problem behavior (Nevin & Wacker, 2013).

Behavioral momentum theory (Nevin & Grace, 2000a) provides a conceptual model for the study of persistence. Studies that investigate behavioral momentum have evaluated a behavior's persistence when challenged (Nevin, Mandell, & Atak, 1983). The most common variable studied relative to behavioral persistence has been rate of reinforcement (Mace et al., 2010; Nevin, 1974; Nevin et al., 1983). Rate of reinforcement is the frequency of reinforcement delivery per unit of time (Mace & Roberts, 1993). Behavioral persistence studies typically are conducted within a multiple schedules design in which two distinct stimuli signal access to reinforcement according to different schedules of reinforcement, with one schedule of reinforcement programmed for a higher rate of reinforcement than the other. After steady state responding has occurred, a challenge condition, such as extinction, is introduced to disrupt responding, and the persistence of responding is calculated for each schedule. Results have shown that more persistent responding occurs under the stimulus condition associated with the higher rate of reinforcement.

Basic studies of behavioral persistence have shown consistent results across species (Cohen, Riley, & Weigle, 1993) and over time (Shahan & Sweeney, 2011), and applied researchers have begun to translate these procedures to treat behaviors of social significance. The initial translations to problems of social significance (Ahearn, Clark, Gardenier, Chung, & Dube, 2003; Mace et al., 2010; Parry-Cruwys et al., 2011; Wacker et al., 2011) have been promising. For example, Wacker et al. (2011) showed the effects of long-term functional communication training on the persistence of task completion for eight children who engaged in problem behavior to escape from demands. Task completion that was challenged by brief periods of extinction persisted during these extinction challenges but sometimes only after almost 18 months of treatment. Similar findings occurred for problem behavior. Studies of persistence and resurgence within a treatment context have extended our knowledge of these important applied issues (Nevin & Shahan, 2011; Nevin & Wacker, 2013).

The variable of stimulus quality is commonly a factor in the success of behavioral treatment programs (DeLeon & Iwata, 1996; Fisher et al., 1992). Stimulus quality is measured by stimulus preference, meaning that a more preferred stimulus is considered to be of higher quality than a lower preferred stimulus (Bowman, Piazza, Hagopian, & Kogan, 1997). Studies have shown that delivering a higher quality stimulus contingent on the occurrence of a target behavior results in greater increases in the rate of that behavior than when a lower quality stimulus is delivered contingent on the same target behavior (Wine & Wilder, 2009). Manipulating stimulus quality, or preference, may also affect rate of reinforcement (Fisher & Mazur, 1997; Nevin & Grace, 2000b) because quality and rate of reinforcement have been shown to be correlated variables (Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994; Nevin & Grace, 2000b). Thus, manipulating the quality of reinforcement may also affect the persistence of behavior (Grace & Nevin, 1997; Nevin & Grace, 2000b). Nevin and Grace (2000b) conducted an evaluation of stimulus quality and persistence within a concurrent chains design. Two choices or components were presented during an initial link. Responding to the initial link produced access to a terminal link, and each terminal link was associated with different reinforcement contingencies that varied in the rate of reinforcer delivery. Results showed that the component during the initial link that led to the terminal link with a higher rate of reinforcement was of higher quality than the other component. Quality was measured in terms of choice allocation to that component. When extinction occurred during the initial link, greater persistence of responding occurred with the component that was associated with the higher rate of reinforcement. These results suggest that stimulus quality is affected by rate of reinforcement, and, thus, it may be reasonable to hypothesize that stimulus quality affects persistence when rate of reinforcement is held constant.

The purpose of this two-experiment investigation was to evaluate differences in the persistence of task completion (a) when extinction followed responding reinforced with either a relatively high or a relatively low quality stimulus (Experiment I), and (b) under extinction conditions when a relatively more or less potent reinforcer was delivered contingent on task completion (Experiment II). Three individuals with reported histories of problem behavior maintained by negative reinforcement in the form of escape from academic tasks participated in each experiment.

Chapter I is divided into four sections. In the first section, I provide an introduction to behavioral momentum theory and describe the initial studies of behavioral persistence with nonhuman subjects. The second section is a discussion of how the theory of behavioral momentum can be applied to humans within a treatment context. In the third section, I provide a discussion of the potential effects of stimulus quality on the persistence of behavior. In the fourth section, I provide a more complete description of the purposes of the current study.

Behavioral Momentum Theory: The Basic Model

Nevin and colleagues provided the initial conceptual model of behavioral momentum theory, relating it to Newton's second law of motion (Nevin, 1974; Nevin et al., 1983). Translated into behavioral terms, change in response rate (i.e., velocity) is directly related to the magnitude of a disruptor (e.g., extinction) and inversely related to the mass (i.e., history of reinforcement) of the behavior (Nevin & Grace, 2000a). Conceptualizing behavior as having mass that affects a behavior's relative persistence underlies the theory of behavioral momentum (Nevin & Grace, 2000a; Nevin & Wacker, 2013).

Most basic studies of behavioral persistence have used a multiple schedules design, with one schedule having a higher rate of reinforcement (i.e., rich schedule of reinforcement) than the other schedule (i.e., lean schedule of reinforcement). In most studies, variable interval (VI) schedules of reinforcement are used, meaning that the display of a target behavior is reinforced after an average interval of time expires. When VI schedules are used, the experimenter controls the number of reinforcers available for consumption during specific time periods, which permits the experimenter to control rate of reinforcement. To compare the relative effects of two or more schedules of reinforcement on behavioral persistence, a challenge condition is conducted after steady state responding has occurred under both schedules. The most common challenges are extinction (Nevin et al., 1983), prefeeding (Igaki & Sakagami, 2004), and distractor stimuli (Mace et al., 1990). To evaluate if one schedule results in greater persistence than the other, the rate of behavior during the challenge is evaluated relative to the baseline rate of responding by calculating proportion of baseline. Baseline represents the rate of responding for the condition immediately preceding the challenge condition (Nevin & Grace, 2000b). Thus, baseline rates are computed for both schedules, and behaviors in both conditions are placed on extinction under each signaled schedule. The signaled condition that yields the smallest proportional change in responding during the challenge condition has the greater persistence.

Rate of reinforcement has been used frequently as an independent variable to study persistence (Dube, Ahearn, Lionello-Denolf, & McIlvane, 2009; Igaki & Sakagami, 2003). These studies have shown that the effects of rate of reinforcement on behavioral persistence are robust (Dube & McIlvane, 2001; Mace et al., 1990) and occur for humans as well as nonhumans. Nevin (1974) provided an early demonstration of persistence related to rate of reinforcement. In a multiple schedules arrangement in which each reinforcement condition was signaled by either a red or a green house light, pigeons were reinforced under VI 1-min (rich) or VI 3-min (lean) schedules of reinforcement. After the pigeons demonstrated steady state responding, all pigeons received response independent access to food during the session to determine if responding would persist more under the richer schedule of reinforcement. Data showed that responding under the VI 1-min schedule persisted for a longer period than responding under the VI 3-min schedule of reinforcement.

Nevin et al. (1983) showed a similar effect with extinction. They trained pigeons to peck a key to earn food reinforcers under either a red light or a green light condition. Rate of reinforcement was manipulated by providing noncontingent reinforcers according to a variable time (VT) schedule of reinforcement when the red stimulus condition was in effect. Thus, rate of reinforcement for key pecking was relatively higher under the red light than under the green light condition. After the pigeons demonstrated steady state responding, key pecking was disrupted by extinction for both stimulus conditions. Results showed that key pecking under the red light condition persisted longer than under the green light condition. This study showed the direct effect of rate of reinforcement on the persistence of key pecking. It also showed that variable time schedules of reinforcement could be used to increase rate of reinforcement.

Mace et al. (1990) provided one of the first translational demonstrations of behavioral persistence with humans. Two adults diagnosed with intellectual disability were reinforced for silverware sorting by receiving access to coffee or other edible reinforcers. For one participant, sorting was reinforced according to a variable interval (VI) 60-s schedule of reinforcement (lean) for red silverware and according to a VI 60-s + VT 30-s schedule of reinforcement (rich) for green silverware. For the second participant, rich and lean schedules of reinforcement were associated with the red and green silverware, respectively. With the added noncontingent reinforcement, rate of reinforcement for silverware sorting was higher under the stimulus associated with the rich schedule of reinforcement than under the stimulus associated with the lean schedule of reinforcement. After steady-state baseline responding occurred, a distractor stimulus (i.e., a Music Television [MTV] program) was introduced into the sessions. The participants were presented with sorting tasks while also being able to watch an MTV show. Results showed greater persistence of silverware sorting under the stimulus associated with the rich schedule of reinforcement. These results showed that behavioral persistence was relevant to applied situations with humans and that various types of socially relevant disruptors are likely associated with decreased persistence.

Translations of Behavioral Momentum Theory to Human Participants

Although the initial findings with humans were promising, much of the research on behavioral persistence was remote from the daily work of applied behavior analysts (Nevin & Wacker, 2013). One goal of applied behavior analysis is to decrease problem behavior and replace problem behaviors with more appropriate behaviors, such as manding (Baer, Wolf, & Risley, 1968). The terminal goal is for appropriate behavior to persist under challenge conditions, such as periods of poor treatment integrity. The behavioral momentum research produced thus far has provided a starting point to conduct these translational investigations.

Ahearn et al. (2003) conducted a study with three participants diagnosed with an autism spectrum disorder who engaged in stereotypic behavior maintained by automatic reinforcement. Cal was diagnosed with pervasive developmental disorder, not otherwise specified (PDD NOS) and engaged in vocal stereotypy in the form of scripted phrases. Edy was diagnosed with PDD NOS and engaged in stereotypic hand movements. Lou was diagnosed with autism and engaged in stereotypic hand movements. During the course of the experiment, each participant was exposed to two experimental sequences (i.e., behavioral momentum [B-MO] sequence and Control sequence). During the B-MO sequence, conditions were conducted in the following order: baseline, VT, test, and baseline. During the Control sequence, conditions were conducted in the following order: baseline, baseline, test, and baseline. During the baseline condition, an experimenter was present but ignored each participant. Conditions that typically evoked stereotypy were created, which involved either no toys (Cal and Edy) or specific toys (Lou). During the VT condition, an item shown to decrease, or compete with, stereotypy through a competing-items assessment was delivered according to a VT 30-s schedule of reinforcement. During the test condition, each participant had noncontingent access to the item used during the VT condition to evaluate the persistence of stereotypy. Stereotypy occurring during the test condition was evaluated as a measure of behavioral persistence. Results showed that the VT condition in the B-MO sequence decreased levels of stereotypy to a greater extent than the baseline condition of the Control sequence. However, stereotypy during the B-MO sequence was more persistent during the test condition than stereotypy during the Control sequence. These data suggested that the addition of the noncontingent reinforcers during the B-MO sequence increased the persistence of stereotypy.

Mace and colleagues (2009, 2010) showed that rate of reinforcement could adversely affect the success of differential reinforcement of alternative behavior (DRA) treatment programs. Three participants diagnosed with developmental disabilities who engaged in severe problem behavior were included in the Mace et al. (2010) investigation. Andy was diagnosed with autism and severe intellectual disability (ID). His target problem behavior was hair pulling. Tom was diagnosed with Down syndrome and ADHD. His target problem behavior was food stealing. Jackie was diagnosed with severe ID, microcephaly, and moderate hearing impairment. Her target problem behavior was aggression. A functional analysis of problem behavior was initially conducted to identify the maintaining contingencies for problem behavior for each participant. Results of the functional analysis showed that each participant's problem behavior was maintained by positive reinforcement. Andy's problem behavior was maintained by adult attention, and Tom's and Jackie's problem behavior was maintained by access to edible reinforcers. A baseline condition was next implemented. During baseline, each participant's problem behavior was reinforced with access to the reinforcer shown to maintain problem behavior. For Andy, hair pulling was reinforced according to a VR 3 schedule of reinforcement with access to attention. Tom's food stealing was reinforced with access to food according to an FR 1 schedule of reinforcement. Jackie's aggression was reinforced with access to food on a VI 60s schedule of reinforcement. A DRA procedure was then implemented to decrease each participant's problem behavior and increase an appropriate behavior. Problem behavior continued to be reinforced according to the baseline schedule of reinforcement. Alternative behaviors and schedules of reinforcement were individually developed. Andy's teacher reinforced appropriate toy play with access to her attention on a VI 30s schedule of reinforcement. Reinforcement for the alternative behavior was provided at an average of 195% of the baseline rate of reinforcement for problem behavior. Tom's appropriate manding for food was reinforced according to an FR1 schedule of reinforcement. Reinforcement for the alternative behavior was delivered at an average of 165% of the baseline rate of reinforcement for problem behavior. Five seconds of appropriate toy play was reinforced according to a VR 2 schedule of reinforcement for Jackie. Reinforcement for the alternative behavior was delivered at an average of 185%

of the baseline rate of reinforcement for problem behavior. An extinction condition followed the DRA treatment for every participant, but the sequence of the DRA, extinction, and baseline conditions varied for each participant. The sequence was baseline, DRA, extinction, baseline, and extinction for Andy, and baseline, extinction, baseline, DRA, and extinction for Tom and Jackie. Results showed greater persistence of problem behavior during extinction when extinction followed DRA treatment for all three participants. DRA treatment was implemented to teach each participant to display a functionally equivalent and appropriate alternative behavior as a replacement for problem behavior. Although quick decreases in problem behavior occurred with DRA treatment, the results also showed an unfortunate side effect of DRA treatment. Reinforcing a functionally equivalent alternative behavior on a rich schedule of reinforcement inadvertently strengthened problem behavior, making it more persistent over time. This is why greater persistence of problem behavior occurred following DRA than following extinction.

One explanation for the results obtained by Mace et al. (2010) and Ahearn et al. (2003) is that the reinforcement provided by the alternative behavior also strengthens all other members of its response class, including problem behavior. Mace et al. (2010) reinforced an alternative behavior using a rich DRA schedule, and Ahearn et al. (2003) delivered a rich schedule of noncontingent reinforcement to decrease stereotypy. Reinforcing a functionally equivalent alternative behavior in the same functional context maintaining problem behavior may inadvertently strengthen problem behavior and result in these problem behaviors being more persistent over time. The implications of these results are especially problematic for applied behavior analysts because the most common treatments used to decrease problem behavior also may increase the strength of problem behavior.

Wacker et al. (2011) evaluated the persistence of both adaptive (manding and task completion) and problem (self-injury, aggression, or property destruction) behavior within a treatment context. Participants were 8 young children diagnosed with autism, ID, or a developmental disability. All procedures were conducted in the home setting by the participants' parents. An initial functional analysis (FA) showed that each participant's problem behavior was maintained, at least in part, by escape from demands. Demands in this project were age-appropriate academic tasks (e.g., stacking blocks, pointing to pictures). Following the FA, an initial extinction condition was implemented in which task completion and problem behavior were placed on extinction. After measures of task completion and problem behavior were obtained during extinction, a functional communication training (FCT) condition was implemented. During FCT, the participant was asked to comply with a small request (e.g., sort one block). Task completion produced access to a microswitch, and touching the microswitch produced a vocal message asking the participant's parent for a brief (2-min) break to play. Problem behavior was placed on extinction during FCT treatment. Demand fading occurred as problem behavior decreased and task completion and manding increased. During early FCT treatment, participants were asked to complete one demand, which was gradually increased to eight demands. The extinction condition was reimplemented at mean time intervals of 2 months, 10 months, and then 16 months. Task completion, manding, and problem behavior continued to be placed on extinction during these sessions. The repeated extinction sessions were implemented to demonstrate the experimental control of the treatment procedures and to evaluate the persistence of task completion, manding, and problem behavior. Results showed decreases in problem behavior and increases in task completion and manding during FCT treatment. However, problem behavior reoccurred quickly during the first extinction session, and corresponding decreases in task completion also occurred. These data showed that treatment effects did not persist for even 5 min after treatment was discontinued. The reimplementation of FCT treatment again resulted in quick decreases in problem behavior and increases in task completion and manding. The lack of resurgence of problem behavior during extinction sessions did not occur until after approximately 16 to 18 months of treatment.

The results presented by Wacker et al. (2011), analyzed via a quantitative analysis, were consistent with behavioral momentum theory. As had been previously shown, problem behavior may have reoccurred during early extinction sessions because of the rich schedule of reinforcement provided for the alternative behaviors. This rich schedule of reinforcement may have inadvertently increased the response strength of problem behavior, and thus very long-term treatment was needed before extinction of problem behavior was sufficient to prevent resurgence. These data provided long-term treatment data showing that behavioral momentum theory can be a helpful conceptual model to account for both the initial and the long-term effects of DRA treatments.

Stimulus Quality and Behavioral Momentum Theory

Stimulus quality is often measured via an analysis of preference (Bowman et al., 1997). Applied behavior analysts conduct preference assessments to identify stimuli that will function as reinforcers for the acquisition of skills during behavioral treatment programs (Fisher & Mazur, 1997). Many different ways of conducting preference assessments have been evaluated in the literature. For example, Fisher et al. (1992) developed the forced choice preference assessment; Windsor, Piché, and Locke (1994) developed the multiple stimulus with replacement preference assessment (MSW); and DeLeon and Iwata (1996) developed the multiple stimulus without replacement (MSWO) preference assessment.

Fisher et al. (1992) showed the usefulness of preference assessment procedures for identifying stimuli that functioned as reinforcers during intervention. Four children diagnosed with moderate to profound ID participated in the first experiment. The purpose of this experiment was to evaluate individual preference for a variety of stimuli that could be used as reinforcers during a behavioral treatment program. During the forced choice preference assessment, each stimulus was paired with all of the other stimuli for a total of

120 pairings. Approaches to one of the stimuli were reinforced with 5 s of access to the selected stimulus. Approaches to both of the stimuli concurrently were blocked. If no approach occurred within 5 s of the choice presentation, the experimenter had the participant sample each stimulus and then re-presented the choice. If no approaches were observed after another 5 s, the stimuli were removed and the next choice was presented. Results showed that this forced choice preference assessment identified a hierarchy of more to less preferred stimuli.

After the preference hierarchy had been identified, Fisher et al. (1992) reinforced sitting in two chairs (i.e., Chairs A and B) according to a concurrent schedules design. Sitting in Chair A led to the delivery of a more preferred stimulus and sitting in Chair B led to the delivery of a less preferred stimulus. Three of the four participants showed greater time allocation to the chair associated with the delivery of the more preferred stimulus. These data showed that preferred stimuli identified via the forced choice method often functioned as reinforcers.

More preferred stimuli also often result in a higher rate of responding than do less preferred stimuli (Wine & Wilder, 2009). For example, Bessie, one of the participants in DeLeon and Iwata (1996), showed that candy was a more preferred stimulus than was juice. Bessie was then reinforced for putting game pieces into a Connect Four game with either the more preferred stimulus (candy) or the less preferred stimulus (juice). Results showed that Bessie engaged in a higher rate of responding when reinforced by the more preferred stimulus (3.2 responses per minute [RPM]) compared to the less preferred stimulus (an average of 0.66 RPM). Thus, Bessie received a higher rate of reinforcement from the more preferred stimulus than from the less preferred stimulus because the preferred stimulus resulted in a higher rate of responding.

Given the effects of preference on rate of reinforcement, it is reasonable to hypothesize that the quality of reinforcement may affect the persistence of responding. This hypothesis has been supported by the results from several studies (Jimenez-Gomez, Podlesnik, & Shahan, 2009; Nevin & Grace, 2000b), but the results were confounded because the authors manipulated both quality and rate of reinforcement. Subjects allocated the majority of their choice responding to access reinforcement delivered according to a richer schedule of reinforcement, but this stimulus condition was also associated with the higher quality reinforcer. Thus, it was unclear which variable accounted for increased persistence.

Mace, Mauro, Boyajian, and Eckert (1997, Experiment 3) isolated the unique effects of stimulus preference on persistence by delivering more and less preferred stimuli on the same schedule of reinforcement. These experimenters began by assessing rats' preference for a sucrose solution or citric acid by measuring consumption of these concurrently available reinforcers. All rats preferred the sucrose solution to citric acid. Next, the rats were trained to press levers to access either the sucrose solution or citric acid within a multiple schedules design. The components of the multiple schedules design were a flickering house light that was associated with 4 s of access to a sucrose solution and a continuous house light that was associated with 4 s of access to citric acid. Lever pressing was reinforced according to a VI 60-s schedule of reinforcement for both components. After the rats demonstrated steady state responding and approximately equal rates of reinforcement for both stimulus conditions, lever pressing for both stimulus conditions was disrupted with extinction. Results showed that stimulus preference positively affected behavioral persistence. Each rat displayed greater persistence of lever pressing under the stimulus condition associated with the delivery of sucrose solution. These data are promising from an applied perspective, because the measurement of stimulus preference is common practice during behavioral treatment programs (Fisher & Mazur, 1997) and more preferred stimuli are often selected as reinforcers.

Purpose of the Study

In the current study, I evaluated the effect of stimulus quality, identified via a commonly implemented preference assessment procedure, on the persistence of task completion during Experiment I. A preference assessment was conducted within a concurrent schedules design to evaluate each participant's relative preference for attention and tangible stimuli. These stimuli were then used to reinforce task completion within a multiple schedules design at approximately equal rates of reinforcement. Extinction was implemented as a challenge condition to measure differences in the persistence of task completion. Task completion with access to attention and tangible items was reinforced at approximately equal rates of reinforcement to isolate the effects of stimulus quality on the persistence of task completion.

Experiment II was an evaluation of the effects of stimulus potency on the persistence of task completion. Preference for an array of tangible stimuli was evaluated using an MSWO preference assessment. The two highest preferred stimuli were then evaluated within a progressive ratio arrangement (Roane, Lerman, & Vorndran, 2001) to measure the potency of each stimulus. These stimuli were then used to reinforce task completion within a multiple schedules design at approximately equal rates of reinforcement. Extinction was implemented as a challenge condition to measure differences in the persistence of task completion.

CHAPTER II

LITERATURE REVIEW

Operant behavior is influenced by a three-part sequence that begins with the presentation of a stimulus. The stimulus evokes behavior that produces either a reinforcing or a punishing consequence. The consequence determines the probability of whether the behavior will occur in the presence of the stimulus in the future (Nevin, 1992, 2012; Nevin & Grace, 2000a). Based on this sequence, researchers have suggested that the two discriminated aspects of operant behavior are response rate and resistance to change (Nevin, 2012; Nevin & Grace, 2000a; Nevin & Wacker, 2013). Response rate is influenced by response – reinforcer relations and refers to the frequency with which a behavior is exhibited. Resistance to change is influenced by stimulus – reinforcer relations and refers to a behavior's persistence (i.e., the continued observation of a behavior) following changes to antecedent or consequence stimuli (Nevin & Wacker, 2013). These two aspects of behavior have been used to describe the construct of response strength (Catania, 1998; Nevin, 1974; Smith, 1974). Response strength is defined as a behavior's resistance to change (Catania, 1998). Studies on response strength show how behavior can be strengthened (Nevin, et al., 1983) or weakened (Mace et al., 2010; Wacker et al., 2011) as measured by its resistance to change.

Behavioral momentum theory was first discussed by Nevin et al. (1983) to describe response rate and resistance to change as they related to response strength (Nevin & Grace, 2000a). Behavioral momentum theory was developed to be analogous to Newton's Second Law of Motion, with response rate representing velocity and resistance to change representing mass in the quantitative formula (Nevin et al., 1983; Nevin & Wacker, 2013). Research on behavioral momentum theory has focused on a behavior's mass (Nevin et al., 1983) and specifically on rate of reinforcement (Nevin & Grace, 2000a; Nevin & Wacker, 2013). Rate of reinforcement is the frequency per unit of time a reinforcer is available and delivered (Mace & Roberts, 1993). In a typical experimental arrangement investigating behavioral momentum theory, a multiple schedules design is used to signal access to a reinforcer according to distinct schedules of reinforcement that vary in the rate of reinforcer delivery. After steady state responding is established in both schedules, a disruptor condition, such as extinction, is implemented to disrupt the response – reinforcer relation and evaluate behavioral mass through its persistence. Research has shown that reinforcing a behavior at a higher rate in a particular context produces greater persistence during challenges than when the same behavior is reinforced at a lower rate in another context (Cohen, et al., 1993; Mace et al., 1990; Nevin et al., 1983; Parry-Cruwys et al., 2011). The original studies on behavioral momentum theory were conducted as basic studies with nonhuman animals. More recently, these studies have been conducted within a treatment context in which relations between rate of reinforcement and the persistence of the alternative behaviors reinforced during treatment were demonstrated. The results of these studies have been helpful for understanding treatment relapse and treatment persistence (Mace et al., 2010; Shahan & Sweeney, 2011; Wacker et al., 2011).

Behavioral momentum theory has shown the robust effect of rate of reinforcement on persistence, and investigations of the effects of other dimensions of reinforcement on persistence are warranted. One common dimension of reinforcement in applied settings is stimulus quality (Mace & Roberts, 1993; Neef et al., 1994). Stimulus quality is often measured through preference, with a more preferred stimulus being one that is consumed more frequently than a lower preferred stimulus (DeLeon & Iwata, 1996; Fisher et al., 1992; Roane, Vollmer, Ringdahl, & Marcus, 1998; Windsor et al., 1994). The effect of stimulus quality on the persistence of behavior has not received much attention in the literature, although the initial findings have been positive. For example, Mace et al. (1997) evaluated rats' preference for sucrose solution or citric acid within a concurrent schedules design. Each rat preferred the sucrose solution, and the sucrose solution was identified as the higher quality reinforcer. These researchers reinforced lever pressing according to the same VI schedule of reinforcement within a multiple schedules design. After the rats showed steady state responding, lever pressing was disrupted by extinction to measure the persistence of lever pressing. Lever pressing persisted longest in the multiple schedules component associated with the delivery of the more preferred reinforcer. These results provided preliminary evidence that quality of reinforcement may influence the persistence of behavior.

If stimulus quality does increase persistence of responding with humans, investigations on how to best evaluate the strengthening effects of stimulus quality within treatment contexts is a logical next line of applied research. One issue related to quality is how to best assess quality with humans (see Chapter I for further description of preference assessments). Researchers have shown that in addition to evaluating choice responding within a concurrent schedules arrangement to identify preference, the reinforcer potency of a stimulus also might be related to quality (Roane, 2008). For example, evaluating the extent to which a reinforcer maintains a target behavior following systematic increases to the ratio requirement (demand) needed to access that reinforcer may be a measure of preference (Roane et al., 2001). If so, then the more potent reinforcer may have greater strengthening effects than the less potent reinforcer, and this difference in potency may not always be associated with preference (e.g., one stimulus may be more preferred within a concurrent schedules design but may not be more potent).

In the following sections, I provide a description of how response strength historically has been evaluated using measures of response rate and resistance to change. In the second section, I describe the effects of a multiple schedules design and rate of reinforcement on persistence. I next provide a description of some of the quantitative analyses commonly conducted in momentum analyses and then provide a rationale for evaluating the effects of other dimensions of reinforcement on persistence. In the fifth section, I describe how stimulus quality may be correlated with potent reinforcers that result in increased response strength. I then provide a conclusion summarizing the material described within this literature review.

Evaluation of Response Strength

Both response rate and resistance to change historically have been used as measures of response strength (Catania, 1998; Killeen & Hall, 2001; Nevin, 1974; Nevin & Wacker, 2013; Smith, 1974; Wenrich, 1963; Wilson, 1954). Researchers have most often considered response strength to be indicated by increases in response rate or the future probability of responding (Killeen & Hall, 2001; Thomason-Sassi, Iwata, Neidert, & Roscoe, 2001; Vaughan & Miller, 1984). However, research on changes in response rate relative to schedules of reinforcement has introduced uncertainty as to how much response rate contributes to response strength. In an early example, Wilson (1954) conducted a parametric study of response strength while reinforcing responding according to fixed interval (FI) schedules of reinforcement. The schedules of reinforcement ranged from FI 0 s to FI 360 s. Results showed an inverse relation between response rate and persistence of behavior during extinction. Thus, response rate was not related to behavioral persistence during extinction, and this finding was replicated by subsequent researchers (e.g., Herrnstein, 1961).

Resistance to change reflects the persistence of behavior (i.e., the continued occurrence of behavior) during changes to antecedent or consequence stimuli (Nevin & Wacker, 2013), and a behavior’s resistance to change can be considered as a measure of response strength (Catania, 1998; Nevin, 1974; Smith, 1974). Nevin (1974) showed that resistance to change was a better measure of response strength than was response rate. Experiment 5 of this multi-experiment study analyzed the persistence of button pecking for four pigeons following manipulations of both response rate and rate of reinforcement within a multiple schedules design. During one component, button pecking was reinforced according to a multiple schedules (mult) VI 1-min differential reinforcement of high rate behavior (DRH) schedule of reinforcement and VI 3-min differential reinforcement of low rate behavior (DRL) schedule of reinforcement. This schedule then was arranged for high rates of pecking to be reinforced according to a higher rate of reinforcement than low rates of pecking. During a second component, pecking was reinforced according to a mult VI 1-min DRL, VI 3-min DRH so that low rates of pecking were reinforced according to a higher rate of reinforcement than higher rates of pecking. The results showed that rate of reinforcement predicted persistence better than response rate.

Nevin et al. (1983) and Fath, Fields, Malott, and Grossett (1983) provided two frequently contrasted studies that show relations between response rate and resistance to change. Both studies used pigeons as subjects and button pecking as the target behavior. Nevin et al. (1983) arranged for two variable interval schedules, each correlated with a component of a multiple schedules design that differed in the rate of reinforcer delivery. Fath et al. (1983) arranged for two schedules of reinforcement, also correlated with a component of a multiple schedules design, which yielded higher or lower response rates and equal rates of reinforcement. Thus, Nevin et al. (1983) isolated the unique effects of reinforcer rate and Fath et al. (1983) isolated the unique effects of response rate. After these researchers established steady state responding, responding was disrupted through a prefeeding procedure to measure the persistence of behavior. Prefeeding occurred by delivering noncontingent food to the pigeons prior to the introduction of the multiple schedules components. Results from Nevin et al. (1983) showed similar response rates between the multiple schedules components and greater persistence of responding during the component associated with the higher rate of reinforcement. In contrast, Fath et al. (1983) showed higher response rates in the predicted component but similar persistence of responding during both schedule components. The combined results from these studies provided clear evidence that response rate and resistance to change are two discriminated aspects of operant behavior and that resistance to change may be a better predictor of response strength than is response rate.

Nevin, Tota, Torquato, and Shull (1990) further showed the independence of baseline rate of responding and resistance to change. Within a multiple schedules arrangement, these authors correlated VI + VT and VI-only schedules of reinforcement with two unique stimuli. The stimulus associated with the VI + VT schedules of reinforcement yielded lower response rates than the VI-only schedule of reinforcement, but yielded a higher rate of reinforcement than the VI schedule of reinforcement alone. The lower rate of responding during the VI + VT component was attributed to the delivery of the noncontingent reinforcer. During prefeeding and extinction challenges, responding was more persistent under the stimulus associated with the lower baseline rates of responding (i.e., the VI + VT schedule of reinforcement). Thus, Nevin et al. (1990) again showed that resistance to change was associated with the overall rate of reinforcement for a stimulus in a specific context and not to the rate of responding.

Basic research on response strength has identified several important aspects of the theory of behavioral momentum. Data from these studies showed that resistance to change may be the best measure of response strength (Nevin, 1974; Smith, 1974) and that baseline response rate may not predict its persistence (Fath et al., 1983). In contrast, rate of reinforcement delivered within a specific stimulus context predicted a behavior's persistence during a challenge condition (Nevin, 1974; Nevin et al., 1990). The overall finding, then, is that the stimulus – reinforcer relations influenced by rate of reinforcement also influence a behavior's persistence.

Behavioral Momentum Theory

Newton's Laws of Motion state that a heavy object has greater momentum than a lighter object (Nevin, 2012; Nevin et al., 1983). When motion is disrupted by an external force, the heavier object will have greater velocity than the lighter object. Nevin et al. (1983) extended this law to describe resistance to change, and this translation has been referred to as behavioral momentum theory (Nevin & Grace, 2000). Behavioral momentum theory predicts that rate of responding is analogous to velocity, and relative resistance to change is analogous to mass (in this case, of a behavior). The definition of behavioral momentum theory highlights two discriminations of operant behavior: response rate and resistance to change. Behavioral momentum theory is typically evaluated within a multiple schedules design in which at least two discriminative stimuli are correlated with different schedules of reinforcement. A disruptor, like extinction, is then implemented to study relative resistance to change or persistence (Nevin & Wacker, 2013).

The Pavlovian relation between stimulus and reinforcer delivery (i.e., stimulus – reinforcer relations) has been central to understanding a behavior's resistance to change (Mace et al., 1990; Nevin, 1974; Nevin et al., 1983; Nevin & Wacker, 2013). This is why most analyses of resistance to change have been conducted within a multiple-schedule arrangement (Nevin & Grace, 2000a). Within a multiple schedules arrangement, two or more antecedent stimuli are correlated with different schedules of reinforcement. The rate of reinforcement per unit of time (i.e., rate of reinforcement) is typically higher for one stimulus. The multiple schedules arrangement has been ideal for the study of resistance to change because the effect of a disruptor can be applied equally to both stimulus conditions to measure resistance to change (Nevin & Grace, 2000a; Nevin & Wacker, 2013).

Cohen et al. (1993) conducted a four-experiment study that showed the importance of the stimulus – reinforcer relations by evaluating persistence across simple and multiple schedules arrangements with both rats and pigeons. Experiments 1 (28 rats) and 3 (14 rats) used rats as subjects, and Experiments 2 (3 pigeons) and 4 (7 pigeons) used pigeons as subjects. The target behavior for rats was lever pressing, and during Experiment 1, the simple schedule arrangements were fixed ratio (FR; i.e., behavior is reinforced following the occurrence of a fixed number of responses) 40, FR 80, and FR 160; variable ratio (VR; i.e., behavior is reinforced following an average number of responses) 40, VR 80, and VR 160; fixed interval (FI; i.e., the first behavior occurring after a fixed time interval expires results in reinforcement) 30 s, FI 60 s, and FI 120 s; and VI 30 s, VI 60 s, and VI 120 s. Each schedule was conducted until steady state responding was obtained and then disrupted with extinction, prefeeding, or response independent food presentation during the sessions that measured the persistence of lever pressing. After responding decreased and stabilized during extinction, the next schedule was implemented and then disrupted until all rats were exposed to each schedule of reinforcement. Results from Experiment 1 showed no consistent differences in the persistence of behavior during disruption, even though behavioral momentum theory would have predicted greater persistence for schedules with higher rates of reinforcement. During Experiment 3, rats were exposed to a multiple schedules arrangement in which lever pressing was reinforced according to FR (e.g., FR 40 and FR 160) and FI (i.e., FR 30 s and FR 120 s) schedules of reinforcement. When the rats demonstrated steady state responding under both schedule arrangements, responding was disrupted by extinction, prefeeding, or response independent food presentation. Under these schedule arrangements, results were consistent with behavioral momentum theory in showing that behavior under the stimulus condition associated with the rich schedule of reinforcement persisted longer than the same behavior reinforced under the lean schedule of reinforcement. These data suggested that the discriminative stimuli associated with each component of the multiple schedules design were essential to the study of persistence. Lionello-DeNolf and Dube (2011) showed these same schedule effects with human participants.

A second property often associated with the signals within a multiple schedules design, stimulus control, appears to be unnecessary in some cases. Doughty, da Silva, and Lattal (2007) showed that rate of reinforcement, and not the discriminative stimuli associated with each signal, was most related to behavioral persistence. Experiment 2 of this study showed that resurgence occurred under stimulus conditions that were associated either with or without reinforcement contingencies. These data were contrary to what was typically predicted by behavioral momentum theory because they failed to show the expected stimulus – response relation. Wacker et al. (2013) replicated these findings by showing that similar levels of resurgence of problem behavior occurred under stimulus conditions that were either associated or not associated with reinforcement contingencies. In this study, three young children (range, 1 – 3 years old) diagnosed with developmental disabilities who engaged in severe problem behavior (self-injury, aggression, and property destruction) received FCT treatment to decrease problem behavior. FCT treatment was conducted within a two-step chain by the participant's parents. First, each participant was presented with a small demand, and completion of the demand produced access to a microswitch to mand for play time. Extinction conditions were alternated with FCT treatment conditions within a reversal design. The extinction sessions were conducted to evaluate (a) the persistence of task completion and manding, and (b) the resurgence of problem behavior. Two types of extinction conditions were conducted. During the switch present extinction condition, an unprogrammed microswitch was available while parents presented task demands (e.g., "put the block in the bucket") every 30 s. Manding, task completion, and problem behavior were placed on extinction. During the no-switch extinction condition, task demands were presented every 30 s with task completion and problem behavior being placed on extinction. There were no opportunities to mand with the microswitch. FCT treatment was then implemented to decrease problem behavior and increase appropriate behavior. Results showed highly individualistic patterns of responding, but similar resurgence of problem behavior in both the switch present and absent extinction conditions. These data supported Doughty et al. (2007) and provided additional evidence suggesting that rate of reinforcement was the critical variable related to behavioral persistence and resurgence.

Resistance to change has been studied in relation to baseline response rate, response rate during disruption, reinforcer rate, and stimulus control within multiple schedules designs across species. In most previous studies, quantitative analyses of changes in behavior were conducted, and these quantitative analyses have evolved over time as increasingly complex formulas depicting behavioral persistence have been developed based on the findings of empirical studies.

Quantitative Analyses of Behavioral Momentum Theory

Previous basic research has shown that response rate and resistance to change are discriminated aspects of operant behavior (Nevin, 1974; Nevin & Shahan, 2011; Nevin & Wacker, 2013; Smith, 1974). A variable known to increase the persistence of responding during disruption is rate of reinforcement (Nevin et al., 1983). When describing the persistence of behavior, the data obtained during disruption are compared to the baseline response rate to measure changes in responding related to the disruptor condition. Thus, analyses of behavioral momentum compare rate of reinforcer delivery, response rate during baseline, and response rate during disruption. Basic researchers use quantitative analyses to compare the effects of these variables on the persistence of behavior (Nevin & Shahan, 2011).

Proportion of Baseline

When steady state responding is disrupted during analyses of behavioral persistence, it is important to compare proportional decreases from baseline levels of responding (Nevin & Shahan, 2011) because baseline rates may differ. Proportion of baseline is a calculation that allows researchers to compare the components of the multiple schedules design by controlling for baseline rate of responding. Equation 1 from Nevin and Shahan (2011) begins to model the effects of a disruptor on responding during each component of the multiple schedules design.

$$\Delta B = -x / m$$

(Equation 1; Nevin & Shahan, 2011)

Within this equation, the ΔB represents the change in response rate during disruption and $-x$ represents the value of a disruptor. The sign of x is negative to show that the disruptor decreases response rate. The value of x increases with time. m represents behavioral mass, which is affected by the rate of reinforcer delivery during baseline. This equation predicts that a behavior with greater mass (i.e., a history of more reinforcement) will persist longer during disruption. Another way of modeling these data was presented in Equation 3 from Nevin and Shahan (2011).

$$B_x/B_0 = 10^{(-x/r\ 0.5)}$$

(Equation 3; Nevin & Shahan, 2011)

B_x represents response rate during disruption, B_0 represents baseline response rate, r represents rate of reinforcement, and x represents the value of a current disruptor. This equation showed that behavioral persistence was directly related to the magnitude of the disruptor (x) and inversely related to the rate of reinforcement (r). Nevin and Shahan (2011) presented hypothetical data in their Figure 1 showing how Equation 3 could be used to predict proportion of baseline during a behavioral persistence analysis conducted within a multiple schedules design. Each of three components of the multiple schedules design were associated with different rates of reinforcement per hour. The rates of reinforcement were 10 per hour (diamonds), 40 per hour (triangles), and 160 per hour (squares). These hypothetical data showed that Equation 3 predicted greatest persistence during the multiple schedules component associated with the 160 reinforcers per hour and least persistence for the multiple schedules component associated with 10 reinforcers per hour.

Modeling the Effects of Differential Reinforcement of

Alternative Behavior (DRA)

Equations 1 and 3 from Nevin and Shahan (2011) provided a model for understanding relations between reinforcer rate, baseline response rate, and response rate during disruption while controlling for baseline response rate within a highly controlled experimental arrangement. The extension of these equations to applied treatment analyses is more challenging because treatment analyses often have concurrent schedules of reinforcement for multiple behaviors that each has its own unique history of reinforcement. For example, problem behavior may be placed on extinction while an appropriate behavior is reinforced according to an FR 1 schedule of reinforcement. This would be a very common schedule arrangement during DRA treatment. In one example, Mace and colleagues (2010) taught three children diagnosed with developmental disabilities an alternative behavior to engaging in problem behavior to gain access to tangible stimuli or edibles. Three conditions were alternated. During the baseline condition, problem behavior continued to be reinforced according to the contingencies of each participant's functional analysis and appropriate behavior was placed on extinction. During DRA treatment, the alternative behavior was reinforced according to a dense schedule of reinforcement while problem behavior continued to be reinforced according to baseline schedules of reinforcement. Extinction followed both the baseline and DRA conditions to evaluate differential persistence effects relative to the presence or absence of DRA treatment. Results showed that problem behavior during extinction following the DRA treatment was much more persistent than problem behavior following baseline. These data suggested that reinforcing the alternative behavior also reinforced all members of that behavior's response class (i.e., behaviors that similarly influence the environment; Catania, 1998), including problem behavior. The purpose of this DRA arrangement was to decrease problem behavior and increase the response rate of the alternative behavior (Wacker et al., 2011). However, as these data and other data sets (Ahearn et al., 2003; Nevin et al., 1990) showed, reinforcing an appropriate behavior in the same context that reinforces problem behavior may inadvertently increase the persistence of the problem behavior. Thus, problem behavior decreases and the alternative behavior increases during DRA treatment, but resurgence (i.e., the re-emergence of a previously extinguished response; Shahan & Sweeney, 2011) occurs when DRA treatment is discontinued.

Wacker et al. (2011) showed another variable that could affect the persistence of treatment effects during their treatment evaluation with young children diagnosed with developmental disabilities. During this study, a treatment program to decrease problem behaviors maintained by negative reinforcement in the form of escape from demands was implemented within a chained procedure. The participants were initially told to complete a small task before a communication device was presented to them to mand for an enriched break with toys and attention. Periodically during treatment, the treatment program was challenged by brief periods of extinction. The data reported from this study suggested that task completion and manding decreased and problem behavior increased during early extinction challenges, and it was not until over a year after beginning treatment that task completion persisted during these treatment challenges and problem behavior failed to re-occur. Thus, time in treatment, which is correlated highest with reinforcement for adaptive behavior but also with extinction for problem behavior, was shown to be an important variable to consider, especially regarding the maintenance of treatment effects.

The investigations conducted by Mace et al. (2010) and Wacker et al. (2011) showed some of the complexities with measuring persistence within an applied setting. The effects of reinforcer rate on both alternative behavior and problem behavior, as well as the overall time in treatment, were shown to be important variables. Changes to the equations modeling persistence needed to be made and Equation 7 from Nevin and Shahan (2011) represented an initial attempt.

$$B_t / B_0 = 10^{(-t(c + dr + pRa) / (r + Ra)\ 0.5}$$

(Equation 7; Nevin & Shahan, 2011)

For this equation, B_t represents behavior over time, B_0 represents response rate prior to the introduction of alternative reinforcers, -t represents time, c represents the disruptive effects of suspending the response – reinforcer contingency, dr represents the discriminability of omitting r reinforcers from a context, pR_a represents the disruptive effects of introducing alternative reinforcers, R_a represents alternative reinforcers, and r represents reinforcer rate. This formula showed relations between the addition of alternative reinforcers into the treatment context as well as time in treatment to the overall persistence of behavior.

Summary

The predictions based on behavioral momentum theory can be modeled using the equations described by Nevin and Shahan (2011). These equations provided quantitative analyses of relations between reinforcer rate, response rate during baseline, and response rate during disruption. During applied analyses, the relations of these variables becomes more complex, in part because of the addition of concurrent schedules of reinforcement for problem behavior and the alternative behavior being reinforced during treatment. In these treatment analyses, the reinforcer rate programmed for one behavior may also reinforce all members of that behavior's response class. Thus, reinforcing an alternative behavior according to a dense schedule of reinforcement increases the likelihood for the resurgence of problem behavior and decreases the likelihood for the persistence of treatment effects to occur. Two solutions to this paradoxical effect of DRA treatment proposed in the literature are to implement treatment for an extended period of time (Wacker et al., 2011) or to conduct the DRA treatment in a second context with no history of reinforcement for problem behavior (Mace et al., 2010; Nevin et al., 1990). Investigating other variables that increase the persistence of behaviors, as analyzed by equations one and three, may provide a third solution to the paradoxical effect of DRA treatment. Reinforcing an alternative behavior with a higher quality reinforcer may increase the rate of an alternative behavior without increasing the rate of reinforcement introduced into the treatment context. Several investigators (DeLeon, Iwata, Goh, & Worsdell, 1997; Roane et al., 2001; Tustin, 1994) showed that human participants were sometimes willing to complete more work to earn a high quality reinforcer. Within this arrangement, the alternative behavior was reinforced according to a lower rate of reinforcement due to the increased ratio between response rate and the delivery of reinforcement. A first step towards evaluating this possibility is to show that reinforcer quality influences the persistence of behavior similarly to rate of reinforcement. If this is the case, then analysis of reinforcer potency would show that stimuli that differ in terms of potency are differentially related to the persistence of behavior. For example, a reinforcer that biases an individual to complete eight times the amount of work should result in greater persistence than a reinforcer that biases an individual to complete only two times the amount of work. If this analysis of potency was conducted within a treatment context, this would also represent an extension of Mace et al. (2010) and Wacker et al., (2011).

Quality of Reinforcement

Basic and translational researchers have shown repeatedly that rate of reinforcement directly influences behavioral persistence (Nevin, 1974; Mace et al., 1990; Nevin & Grace, 2000b). Investigations of behavioral persistence have been conducted with a variety of subjects, ranging from nonhuman animals (Nevin, 1974; Cohen et al., 1993) to humans (Mace et al., 1990; Parry-Cruwys et al., 2011) and have been extended to treatment contexts (Ahearn et al., 2003; Mace et al., 2010; Wacker et al., 2013; Wacker et al., 2011). The success of these initial translations has led researchers to study other variables that may affect the persistence of behaviors, such as stimulus quality (Mace et al., 1997). Preliminary research findings on the effect of stimulus quality on persistence have been promising.

Stimulus quality is an important clinical variable in the field of applied behavior analysis (Mace & Roberts, 1993). Stimulus quality has been shown to affect choice responding (Gardner, Wacker, & Boelter, 2009; Neef et al., 1992; Peterson, Frieder, Smith, Quigley, & Van Norman, 2009) and response rate (DeLeon & Iwata, 1996; Fisher et al., 1992; Roane et al., 1998). For example, Neef et al. (1992) showed that three adolescents diagnosed with serious emotional disturbance made choices that were influenced by quality of reinforcement. Completing math problems was reinforced according to two conditions conducted within a concurrent schedules design. During the first condition, yellow note cards were paired with a VI 30-s schedule of reinforcement and green note cards were paired with a VI 120-s schedule of reinforcement. Task completion for either component was reinforced with a nickel (high quality) or a token (low quality). During the second condition, yellow note cards continued to be paired with the VI 30-s schedule of reinforcement but were now paired with the delivery of the tokens. The green note cards continued to be paired with the VI 120-s schedule of reinforcement and were paired with the delivery of nickels. During the first condition, results showed that choice responding was allocated to the component associated with the highest rate of reinforcement, but during the second condition, choice allocation was associated with the delivery of nickels. This allocation occurred even though it was associated with the lower rate of reinforcement. These data showed that stimulus quality biased choice responding from a higher to a lower rate of reinforcement. In general, research has shown that delivering a higher quality stimulus (e.g., highly preferred tangibles) functions as a better reinforcer than a lower quality stimulus. For this reason, applied behavior analysts have often evaluated stimulus quality through stimulus preference assessment procedures and then delivered preferred stimuli as reinforcers (Fisher & Mazur, 1997).

The applied research literature typically defines stimulus quality in terms of preference, with a higher quality stimulus being more highly preferred or chosen more often than a lower quality stimulus (Bowman et al., 1997). For this reason, the applied literature contains many types of stimulus preference assessment procedures to identify high quality stimuli (DeLeon & Iwata, 1996; Fisher et al., 1992; Roane et al., 1998; Windsor et al., 1994). In addition to the accurate evaluation of stimulus quality, researchers have evaluated the use of higher or lower quality stimuli during behavioral treatment programs. Research has shown that delivering a higher quality stimulus functions as a better reinforcer more often than delivering a lower quality stimulus. For this reason, applied behavior analysts frequently have evaluated stimulus quality through stimulus preference assessment procedures and then delivered preferred stimuli as reinforcers (Fisher & Mazur, 1997).

Preference, Reinforcer Potency, and Behavioral Persistence

Several similarly preferred stimuli can maintain responding at approximately equal rates under low response requirements (DeLeon & Iwata, 1997; Roane et al., 2001; Tustin, 1994). These same stimuli may differ in the extent to which they maintain responding following increases to response effort. For example, Roane et al. (2001) demonstrated changes in preference following systematic increase to the ratio requirement to access these stimuli. A forced choice preference assessment showed that two stimuli were equally preferred under low response requirements (i.e., FR 1). However, preference for one of the two stimuli emerged as the ratio requirement to access these reinforcers increased. These authors discussed this effect in terms of reinforcer potency. A more potent stimulus is one that maintains responding at a higher ratio requirement than another stimulus (Roane et al., 2001).

Behavioral economic analyses provide one way to measure the potency of a stimulus. During a behavioral economic analysis, relations between consumption of a stimulus and the unit price to access that stimulus are studied (Madden, Bickel, & Jacobs, 2000). Unit price represents the ratio of work tasks to amount of reinforcement (Francisco, Madden, & Borrero, 2009). For example, completing one math problem to earn 1 min of reinforcement is a unit price of one. The effects of unit price have been widely studied and are often based on the three predictions discussed by Madden et al. (2000): (a) Increasing the unit price to access a stimulus decreases consumption of that stimulus, (b) unit price predicts consumption regardless of the specific values of work, and (c) choice responding will be allocated to the choice option associated with the lower unit price.

Relative to the first prediction, Piazza, Roane, Keeney, Boney, and Abt (2002) showed that changes in unit price affected the frequency of pica with three individuals diagnosed with developmental disabilities. A functional analysis of pica for all three participants showed that pica was maintained by automatic reinforcement. Rates of pica were then evaluated when the response effort to engage in pica was increased. In the low effort condition, all pica items were freely available to the participants. In the high effort condition, two of the participants had pica items placed in sealed plastic containers, and pica items were placed out of reach for the third participant. An alternative, high quality stimulus was also available according to the same low and high effort conditions. The purpose of this evaluation was to determine the conditions under which participants allocated away from pica and toward the alternative stimulus. Results showed that when the unit price to access the pica items was increased, the participants were more likely to engage with the alternative stimulus. These data supported the first prediction of Madden et al. (2000) and showed that evaluations of unit price can be clinically relevant.

The results of the Piazza et al. (2002) study showed that pica items were consumed only when the unit price to access those items was low or when the unit price to access the alternative items was high. Another way to analyze these data is via demand curves that plot the elasticity of a stimulus (Francisco et al., 2009). The portion of the demand curve in which the slope is increasing during systematic increases to unit price is called the inelastic portion of the demand curve. In contrast, the portion of the demand curve in which the slope is decreasing is called the elastic portion of the demand curve. Research has shown that the elasticity of a stimulus may be related to the potency of the stimulus, with a more potent stimulus having greater inelasticity.

Nevin (1995) described how behavioral economics researchers might evaluate data conducted within a behavioral persistence paradigm as suggesting that a rich schedule of reinforcement makes its corresponding stimulus more potent than the stimulus associated with the lean schedule of reinforcement. Thus, rate of reinforcement associated with a stimulus condition changes the potency of that stimulus during a challenge condition (Nevin, 1995). My supposition is that stimulus quality may be another variable that moderates the value of a stimulus (Neef et al., 1992; Roane, et al., 2001). Research has shown that preferred stimuli vary in their potency. What has not been shown is if the potency of a preferred reinforcer affects persistence during challenge conditions within an analysis of behavioral persistence.

Stimulus quality has received considerable attention in the literature as an important variable associated with the success of treatment (Fisher et al., 1992; Pace et al., 1985). For example, Fisher and colleagues (1992) showed that individuals responded at a higher rate for a more preferred stimulus compared to a less preferred stimulus. Interestingly, though, some studies have shown that stimuli identified as less preferred maintained responding equally as well as high-preferred stimuli (DeLeon et al., 1997). One possible explanation for these results is that although the stimuli differed in level of preference, they had equal potency. Behavioral economics studies of preference present an alternative way to measure potency in these situations. Although many stimuli identified as more or less preferred may maintain responding at low response requirements (e.g., FR 1), they often differ in how well they maintain responding at higher response requirements (e.g., FR 20). Studies of stimulus potency may identify stimuli that are not only preferred but that also result in behavioral persistence as response requirements are increased. If so, these results would extend our knowledge of behavioral persistence to include high-preferred stimuli as being more potent than less-preferred stimuli. Modifications to the quantitative analyses presented by Nevin and Shahan (2011) could also be made to determine the variance accounted for by quality of reinforcement.

A progressive ratio arrangement may provide one way to measure the potency of stimuli. In a progressive ratio arrangement, the ratio requirement to earn a particular stimulus is systematically increased (Roane, 2008). The more potent stimulus is defined as the stimulus that maintains responding at the highest ratio requirement. Thus, studies of stimulus potency often use a combined progressive ratio and concurrent schedules arrangement. Measuring responding in this way provides a way to gauge both preference and potency (Glover, Roane, Kadey, & Grow, 2008; Penrod, Wallace, & Dyer, 2008). Choice allocation should correspond with preference (Fisher & Mazur, 1997), and responding under systematically increasing response requirements should provide a measure of potency.

A two-experiment investigation by Roane et al. (2001) evaluated stimulus potency with four individuals who were diagnosed with a developmental disability and engaged in problem behavior. Following a forced-choice preference assessment in Experiment 1, two of the most preferred stimuli were selected to serve as reinforcers for task completion during a reinforcer assessment. During the reinforcer assessment, the ratio requirement to access both reinforcers was systematically increased. At a relatively low response requirement (e.g., FR 1), all four participants responded approximately the same amount and accessed about the same number of reinforcers. As the ratio requirement to access the reinforcers increased, participants began allocating more of their responding to one of the stimuli. For example, at FR 1, one participant, Sandie, responded equally to access a teether or a musical toy. However, as the ratio requirement to access both stimuli increased, Sandie began responding more for the teether. These data suggested that the teether was a more potent reinforcer because this item maintained responding at a higher ratio requirement than did the musical toy.

Experiment 2 of Roane et al. (2001) evaluated the effects of the reinforcers during a behavioral treatment program conducted for three of the participants. The purpose of Experiment 2 was to evaluate if the reinforcer identified as more potent in Experiment 1 was more effective in decreasing problem behavior during a DRA intervention program. Following a functional analysis of problem behavior, the DRA treatment was implemented using both of the reinforcers evaluated in Experiment 1 within a multiple schedules design. The previously identified more potent reinforcer resulted in greater decreases in problem behavior than the relatively less potent reinforcer for all three participants. These data suggested that reinforcers that maintain responding at relatively higher response requirements might result in greater reductions in problem behavior during behavioral intervention programs.

The investigation by Roane et al. (2001) showed that preference may influence reinforcer potency; the relatively more potent reinforcer maintained task completion at a higher ratio requirement and decreased problem behavior better than the relatively less potent reinforcer. Thus, greater persistence occurred for the more potent reinforcer when the challenge was increased effort. These results suggest that more potent reinforcers should be related to greater behavioral persistence, but this relation remains largely unknown and warrants further investigation.

Conclusion

To date, translations of behavioral momentum theory have focused almost exclusively on the effects of reinforcer rate on the persistence of alternative and problem behavior during challenge conditions. Although researchers have begun to study the effects of challenge conditions other than extinction (e.g., Mace et al. 1990; Wacker et al., 2011), few studies have addressed reinforcer dimensions other than rate of reinforcement. Quality (i.e., preference) of reinforcement has been shown to be an important variable during behavioral treatment programs as more preferred and more potent reinforcers increase responding relative to less preferred reinforcers. As such, delivering a more preferred or potent reinforcer contingent on a target behavior may increase the rate of target behavior and, thus, expose the behavior to high rates of reinforcement. Thus, greater persistence may be achieved with more preferred or potent reinforcers. The effect of stimulus quality on behavioral persistence has been largely unstudied, and investigations that have been conducted are confounded with rate of reinforcement. The current project was conducted within two experiments. During Experiment I, I evaluated preference for adult attention versus tangible items using a concurrent operants assessment. Task completion was then reinforced with attention or tangible items within a multiple schedules design according to the same schedule of reinforcement. Extinction was used to evaluate the persistence of task completion for the stimulus associated with the more or less preferred class of stimuli. Thus, the experimental question asked whether more or less preferred classes of stimuli differentially strengthened task completion. During Experiment II, I conducted a behavioral economics analysis of stimulus potency within a concurrent schedules design. Task completion was reinforced with access to the more and less potent stimuli within a multiple schedules design and according to the same schedule of reinforcement. Extinction was used to evaluate the persistence of task completion under the stimulus associated with the more or less potent stimulus. Thus, the experimental question asked whether more or less potent stimuli differentially strengthened task completion.

CHAPTER III

METHODOLOGY

Experiment I

Participants

Participants were referred to the study by clinic staff from either a Pediatric Psychology outpatient clinic or a BioBehavioral Day Treatment clinic at the University of Iowa Hospitals and Clinics (UIHC). Participants met the following inclusion criteria: were between 2 and 35 years old and had a reported history of displaying problem behavior when presented with work tasks.

Aida was a 6-year-old girl in the first grade. She was diagnosed with attention deficit/hyperactivity disorder (ADHD), dysnomia, and dyslexia. Aida's mother reported that destructive problem behavior was aggression (e.g., hitting) and property destruction (e.g., tearing work tasks, pounding hands on table). Disruptive problem behavior was noncompliance (e.g., refusing to complete teacher directions) when presented with academic tasks. She received Ritalin during her participation in the current investigation.

Sarie was a 7-year-old girl in the second grade. She was diagnosed with dysnomia. Sarie's destructive problem behavior was aggression (e.g., pushing). Her disruptive problem behavior was noncompliance (e.g., refusing to complete teacher directions) when presented with academic tasks.

Darren was a 2-year-old boy. He was diagnosed with macrocephaly, disruptive behavior disorder, stereotypic movement disorder, and developmental delays. Darren's destructive problem behaviors were aggression (e.g., hitting, kicking, biting) and property destruction (e.g., throwing or tearing items). Disruptive problem behavior was noncompliance when presented with task demands.

Setting and Materials

Experimental procedures were conducted either in a clinic therapy room at the Center for Disabilities and Development (CDD) on the campus of UIHC or at the participant's home. Members of the research team conducted experimental sessions during 1- to 2-hr weekly or bi-weekly visits for an average of 5.7 months (range = 5 to 6 months). An average of 4.3 sessions was conducted during each weekly visit (range = 1 to 8).

Initial sessions with Aida and Sarie were conducted at the CDD. Sessions were subsequently conducted in their homes based on parent preference. All of Darren's sessions were conducted at the CDD. Sessions at the CDD were conducted in clinic therapy rooms. Each therapy room contained a table and four chairs on one side of the room, and preferred activities were placed on a padded mat on the other side of the room. Therapy rooms were equipped with a ceiling mounted video camera and microphone that permitted observations from an adjacent room and video recording of sessions. Sessions at home were conducted in the participant's kitchen. Sarie's kitchen consisted of a table approximately 1.5 m x 0.91 m with four chairs surrounding the table. Aida's kitchen consisted of a table approximately 2.1 m x 1.2 m with six chairs surrounding the table. For both Sarie and Aida, toys were placed on the table or on the kitchen floor next to the table. A digital camera (Cisco Flip Video Camera) was used to digitally record all sessions conducted at the participants' homes. A digital timer was used to signal the beginning and end of the experimental sessions.

Leisure Items

I used the MSWO preference assessment (DeLeon & Iwata, 1996) to identify tangible items that were relatively more preferred, relatively medium preferred, and relatively less preferred by the participants. Tangibles for Aida were puzzles, coloring/painting materials, a tool set, a toy farm set, and music toys (e.g., a toy guitar). Tangibles for Sarie were puzzles, Barbie dolls, baby dolls, a Leap Frog game, and dominoes. Tangibles for Darren were a pirate ship, trains, farm set, cars, and action figures.

Work Tasks

The work tasks were based on parent report of academic tasks that were (a) associated with problem behavior in the classroom or at home and (b) tasks that the participant could complete independently. Work tasks for Aida were counting worksheets, reading comprehension worksheets, and matching worksheets. Work tasks for Sarie were coin-counting worksheets, reading comprehension worksheets, and spelling worksheets. Darren's work task was putting blocks in a bucket.

Tokens

Participants had access to 18 total tokens, nine yellow and nine orange, over the course of Experiment I. Each token was a square shape with a 5 cm x 5 cm circle drawn on the token. A black "+1" was drawn inside each circle. Yellow tokens were used to signal access to adult attention. Orange tokens were used to signal access to tangible items.

Dependent Variables

Response Definitions

Data were collected on choice, time allocation, problem behavior, and task completion. Choice was defined as making a vocal or gestural selection (e.g., pointing) toward one of two concurrently available choice options. Time allocation was defined as spending at least 3 consecutive seconds engaging with one of two concurrently available choice options. Problem behavior was defined as destructive or disruptive behavior. Destructive behavior for Aida was aggression and property destruction. Aggression was defined as her hand or foot coming into contact with the therapist. Property destruction was defined as her hand forcefully coming into contact with the table or tearing a work task. Destructive behavior for Sarie was aggression. Aggression was defined as her hands coming into contact with the therapist. Darren's destructive problem behaviors were aggression and property destruction. Aggression was defined as his hand forcefully hitting the therapist or his mouth closing on the therapist's arm or leg. Property destruction was defined as knocking over tables and throwing work tasks. Disruptive behavior for all three participants was defined as noncompliance (i.e., 3 s of not attending to or completing a task). Task completion was defined as completing all items on an individual worksheet (Aida and Sarie) or placing a block appropriately into the bucket (Darren). Leaving an item on a worksheet blank (Aida and Sarie) or engaging in destructive problem behavior while completing a task precluded task completion from being scored. Accuracy did not affect task completion.

Data Collection and Inter-Observer Agreement (IOA)

All sessions were digitally recorded using the audio-visual equipment at the CDD or using a handheld video recording device. Data were collected in vivo and via digital recordings. A 6-s partial-interval data recording system was used to code the data.

Choice data were collected during the MSWO preference assessment using an event-recording procedure. Each tangible item selected by the participants was recorded according to the order in which it was selected. For example, if Aida chose to play with art supplies first, this item was recorded as a “1.” The last tangible item selected was recorded as a “5.”

Choice data during the concurrent operants assessment of play and work were recorded using an event-recording procedure. The choice between completing work alone or playing with a toy alone was recorded by noting which choice was made and was calculated as total frequency of choice responding.

Time allocation and problem behavior data were recorded using a 6-s partial-interval data recording system. Data recording sheets were divided into fifty 6-s intervals for each 5-min session. Data on time allocation between the concurrently available choice options were reported as percentage of intervals. Problem behavior was reported as the combined percentage of intervals of destructive and disruptive problem behavior.

Task completion data were collected using an event-recording data collection system. Observers recorded when task completion occurred by placing a check mark on the 6-s partial interval data recording system above the 6-s interval in which task completion occurred. Data on task completion were reported as frequency of task completion. Frequency of task completion was computed by adding the total number of tasks completed during each session.

IOA was completed by two independent observers on at least 30% of all sessions for each condition. IOA for choice and task completion were obtained via exact interval-by-interval comparisons of both observers' data across each of the dependent variables. An agreement was defined as occurring when both observers recorded the same behavior in the same 6-s interval. A disagreement occurred when only one of the observers recorded a behavior in the 6-s interval. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying the total by 100%. For Aida and Sarie, IOA was 100% for choice and task completion. For Darren, IOA for choice was 100% and IOA for task completion averaged 97.4% (range, 80% - 100%).

IOA for time allocation was obtained using an exact interval-by-interval comparison. An agreement was defined as both observers scoring the same behavior in the same 6-s interval. A disagreement occurred if only one of the observers scored the behavior in a 6-s interval. IOA for time allocation was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying the total by 100%. For Aida, IOA for time allocation averaged 99.8% (range, 96% to 100%) and IOA for problem behavior averaged 99.1% (range, 89% - 100%). For Sarie, IOA for time allocation was 100% and IOA for problem behavior averaged 99.2% (range, 80% - 100%). For Darren, IOA for time allocation averaged 99.5% (range, 96% - 100%) and IOA for problem behavior averaged 98.9% (range, 90% - 100%).

Design and Analysis

Experiment I was conducted in seven phases. During Phase 1, I conducted a MSWO preference assessment within a concurrent schedules design. Each tangible item included during the MSWO preference assessment was available until it was selected, and then it was removed from the array of toys available. Selection was coded in a hierarchical manner, with the toys chosen first through fifth listed in the hierarchy.

Phase 2 was the concurrent operants assessment of play and work and was conducted within a concurrent schedules design. Participants were asked to choose between completing work or playing with a preferred item or activity. Five choices were conducted in a session and frequency data were recorded for each choice option selected (i.e., 0 – 5).

Phases 3 (time contingent reinforcement analysis) and 4 (positive reinforcement analysis) were each conducted within a multiple schedules design. The components of the multiple schedules design for Phase 3 were delivering orange tokens and delivering yellow tokens contingent on task completion, with tokens signaling different schedules of reinforcement in each phase. During Phase 3, differences in frequency of task completion were recorded when only one of the colored tokens was delivered contingent on task completion (i.e., no other reinforcers were provided). Orange and yellow sessions were counterbalanced, and data were represented as frequency of task completion (i.e., 0 to 9 tasks completed). The purpose of the time contingent reinforcement analysis in Phase 3 was to determine if differences in task completion occurred, showing that the participant had a color preference.

The same components of the multiple schedules design were used during Phase 4, but the tokens now signaled that the same schedule of positive reinforcement would be delivered for task completion. Phase 4 was conducted to (a) establish the same history of reinforcement with each set of colored tokens, (b) control for rate of reinforcement (FR 1 schedules), and (c) show that no systematic differences in the frequency of task completion occurred for sessions conducted with either the orange or the yellow tokens.

During Phase 5, a concurrent operants preference assessment of tangible items and attention was conducted within a concurrent schedules design to show each participant's relative preference for toys and attention. To partially control for sequence effects, the order of presentation of the choices was counterbalanced such that each choice was presented first or second an equal number of times. Similarly, the choices were presented to the participant's right and left sides an equal number of times. Data for the concurrent operants preference assessment were represented as percentage of time allocation. Percentage of time allocation was calculated by the number of intervals a participant spent engaging with one of the two concurrently available choice options divided by the total number of intervals.

During Phase 6, a disruptor analysis was conducted within a multiple schedules design to evaluate differences in the frequency of task completion when task completion no longer resulted in reinforcement. The disruptor was extinction. Orange and yellow sessions were counterbalanced to control for sequence effects. Data were represented as proportion of baseline. Proportion of baseline was calculated by dividing the number of tasks completed during each extinction session by the average number of tasks completed during the positive reinforcement schedule analysis (Phase 3) for both the yellow and the orange tokens. The formula for proportion of baseline was the frequency of task completion during each orange or yellow context session during extinction divided by the mean frequency of task completion in the orange or yellow context during the positive reinforcement analysis (Nevin & Grace, 2000a). During Phase 7, re-implementation of treatment contingencies occurred to show an increase in task completion and a decrease in problem behavior following the disruptor analysis.

Procedures

Consent Process and Initial Interview

When the participant and his or her legal guardian reported for their first visit, one member of the research team played with the participant while another member of the research team reviewed the consent materials with the participant's guardian. The guardian and the consenting member of the research team reviewed the consent materials in a quiet room at the CDD. If the participant's guardian had questions about the current study, these were addressed during this meeting. After the guardian signed the consent document, the consenting member of the research team greeted the participant. If the participant was 6 years of age or younger (Aida and Darren) at the time of consent or did not have the ability to provide assent, the consenting member of the research team initiated an informal interview with the participant's guardian. If the participant was older than 7 years of age (Sarie), the consenting member of the research team met with the participant to complete the assent document. The assent document was completed with the participant's guardian present in the same quiet room in which informed consent was obtained. Any questions from the participant were answered during this meeting. After the assent document was signed, the participant returned to playing with a member of the research team while the consenting member of the research team initiated an informal interview with the guardian. The parent interviews were approximately 10 to 15 min in duration. The interviewer asked about the toys and activities the participants enjoyed engaging with on a regular basis and the work activities that were typically associated with the onset of problem behavior at home or school.

Multiple Stimulus Without Replacement Preference Assessment (Phase 1)

An MSWO preference assessment (DeLeon & Iwata, 1996) was conducted at the beginning of each visit while participants were completing the concurrent operants assessment of play and work. The purpose of the MSWO preference assessment was to identify relatively more-preferred, medium-preferred, and less-preferred tangible items to use during the concurrent operants assessment of play and work. At the outset of each visit, the participants were directed to a clinic therapy room at the CDD. The participants were then presented with five toys and were allowed to freely engage with these items. Following approximately 2 min of play time, the participant was directed to stand next to a therapist, who was a member of the research team, in the middle of the therapy room.

The therapist lined up each of the toys available to the participant in a straight line approximately 3 to 4 ft in front of them. The therapist named each toy for the participant and asked which toy he or she wanted to play with the most. After the participant made a selection, the participant was allowed to play with the selected item for 30 s while all other toys were placed out of reach by the therapist. The participant received continuous therapist attention during this 30-s play period. Following the conclusion of the play period, the therapist placed the toy the participant was playing with on the opposite side of the therapy room. The participant was again directed to stand in the middle of the therapy room and the process was repeated until all of the toys had been selected by the participant. If a participant refused to make a choice, then the therapist waited 30 s and ended the MSWO preference assessment. Relatively more-preferred tangible items were defined as those chosen first and second during the preference assessment, medium-preferred tangible items were defined as those chosen third or fourth during the preference assessment, and less-preferred tangible items were defined as those tangible items chosen last.

Concurrent Operants Assessment of Play and Work (Phase 2)

The concurrent operants assessment of play and work began immediately following the MSWO preference assessment. The purpose of the concurrent operants assessment of play and work was to identify the conditions under which each participant chose to avoid a work task. Each session of the concurrent operants assessment of play and work consisted of five 1-min trials. Each trial began with the therapist dividing the therapy room into two equal parts. The room was divided by a mat or chair placed in the middle of the therapy room. The therapist then directed the participant to the middle of the therapy room. One side of the room contained the less-preferred tangible item (i.e., the toy chosen last during the preceding MSWO preference assessment) and the other side of the room contained a table and academic worksheet for the participant to complete. For Aida only, medium- and high-preferred tangible items were also used during this phase. The therapist then asked the participant to choose either side of the room. After the participant made a choice, the therapist left the therapy room or faced away from the participant for the remainder of the 1-min trial. If no choice was made, the therapist presented the choice one more time and then left the room or faced away from the participant. When 1 min expired, the therapist re-entered the therapy room or turned around to face the participant. The participant was again directed to the middle of the therapy room, and the therapist replaced the academic worksheet with another worksheet even if the participant did not choose to work during the previous trial. The order of presentation for the choices was counterbalanced such that each choice was presented first and second an equal number of times. Similarly, the choices were presented to the participant's right and left sides an equal number of times. This procedure was repeated until five trials had been conducted. The participant was allowed to engage in a brief play time with toys and attention after the fifth trial before another session of five trials was conducted. The concurrent operants assessment of play and work was conducted until the participant chose to play for at least four out of the five trials during at least three of four consecutive sessions.

Time Contingent Reinforcement Analysis (Phase 3)

At the beginning of each session, the participant was directed to either a work table in the therapy room or the kitchen table at his or her home. All toys and activities were collected and moved out of the participant's line of sight. A set of nine worksheets (Aida and Sarie) or nine blocks (Darren) was then presented to the participant. Each worksheet contained from five to 12 items. Yellow or orange tokens, depending on the condition, were arranged in a semi-circle around the worksheets. Instructions for how to complete the work tasks were reviewed with each participant and he or she was asked to complete one item on each worksheet or place one block in the bucket. If necessary, corrective feedback was provided after completion of this item. This introduction was done to make sure the participants understood how to complete their work task.

Following this introduction, the participant was told that he or she could complete as many or as few of the work tasks as he/she wanted. The participant was subsequently alerted to the color of the tokens (e.g., “Look, the yellow tokens are out this time”). No additional information about the purpose of the tokens was given to the participant. The therapist then restricted his or her attention and allowed the participant to work alone. Problem behavior and all questions asked by the participants were ignored. Time contingent reinforcement sessions were 5 min in duration. When 5 min expired, the participant was allowed to play for 2 min, as signaled by a timer, with all the available toys. The tangible items and the therapist’s attention were reintroduced at this time. Problem behavior continued to be ignored during play time. When the timer sounded, toys and attention were restricted and the previously described procedures were conducted again. These sessions were repeated until task completion occurred at a similar frequency for both yellow and orange sessions.

Positive Reinforcement Analysis (Phase 4)

The participant was told that the yellow and orange tokens now signaled the type and amount of reinforcement available contingent on task completion. The yellow tokens signaled access to attention, and the orange tokens signaled access to tangible items. One token was earned after completing each worksheet, and each token represented 1 min of time with attention or tangible items.

At the outset of each session, the therapist directed the participant to a table. The same set of nine worksheets or blocks used during the time contingent reinforcement analysis was placed in front of the participant. Each participant was told what the token represented prior to the beginning of each session. For example, the therapist said, “Look, the orange tokens are out. Orange tokens mean you will earn time with your toys for finishing your work.” The participants were then told to complete as much or little of the work as they wanted. Therapist attention was restricted by turning away from the participant. Problem behavior and all questions directed to the therapist were ignored. After 5 min had passed, the therapist instructed the participant to stop working. The therapist then provided corrective feedback and counted the number of work tasks the participant had completed. The participants were told how much time in reinforcement they had earned. If the participant earned yellow tokens, the participant and therapist talked for the amount of time earned. If the participants earned orange tokens, attention was restricted but the participants were allowed to interact with the tangible items for the amount of time earned. Problem behavior during reinforcement time was ignored. Positive reinforcement analysis sessions continued until a very similar amount of reinforcement (i.e., within 1.0 minute) occurred for yellow and orange sessions for three consecutive sessions.

Concurrent Operants Preference Assessment of Tangible Items and Attention (Phase 5)

The purpose of the concurrent operants preference assessment of tangible items and attention was to evaluate each participant's relative preference for attention or tangible items. At the outset of each session, the clinic therapy room (Darren) or the participant's kitchen table (Aida and Sarie) was divided into two equal halves. The clinic therapy room was divided by a chair or piece of tape being placed in the middle of the room. The kitchen table was divided by having two chairs present on opposite sides of the kitchen table. Sessions began with the therapist placing tangible items on one side of the room or table and directing the participant to the middle. The participants were told that if they chose to play on the side of the table with toys, they could play with the toys by themselves or they could choose the side of the table with no toys and talk with the therapist (and mother for Darren) without any toys. The side of the table with attention and tangible items and the order of presentation of the choices were counterbalanced. After the participants made their choice, the therapist sat on the attention side of the table. The participants were allowed to freely allocate their time between both sides of the table. Approximately half way through the session, the therapist reminded the participants that they could engage with the activity on the opposite side of the table if they wanted. After 5 min had passed, the participants were directed to the middle of the kitchen table and the procedures were repeated. Sessions were conducted until the participant allocated greater than 50% of session time to one reinforcer for three consecutive sessions.

Disruptor Analysis (Phase 6)

The purpose of the disruptor analysis was to evaluate the persistence of task completion when reinforcement contingencies for task completion were discontinued. At the outset of each session, the participant was presented with the same set of nine worksheets or blocks used during the previous phases of the current study and the same yellow and orange tokens. Prior to each session, participants were reminded of the reinforcer that each colored token signaled (i.e., yellow = attention; orange = tangible items) and that they could complete as many or few work tasks as they liked. The therapist subsequently restricted his or her attention while the participant completed the worksheets alone. Problem behavior was ignored during these sessions. Each session was 5 min in duration. When the 5 min expired, the participant’s work was checked for accuracy. The next session began immediately following the end of the previous session and continued for up to seven sessions during each visit. Sessions continued until either (a) task completion decreased to zero for three consecutive sessions, or (b) task completion under one stimulus condition (e.g., yellow) was less than under another stimulus condition (e.g., orange) for three consecutive sessions.

Re-Implementation of Treatment Contingencies (Phase 7)

Following the end of the disruptor analysis, a DRA intervention was implemented to increase task completion and decrease any problem behaviors that emerged during extinction. The DRA intervention was modeled after the positive reinforcement analysis. Participants were presented with nine worksheets or blocks and asked to complete as many as they could for 5 min. No tokens were delivered during this time. Therapist attention was also restricted during this time. Following the 5-min period, the participants received 1 min of time with both attention and tangible items for each task they completed. Phase 7 continued until the participant's task completion increased to levels previously observed during the positive reinforcement analysis.

Experiment II

Participants

Participants were referred to the study by clinic staff from either a Pediatric Psychology outpatient clinic or the BioBehavioral Day Treatment clinic at the UIHC. Participants met the following inclusion criteria: were between 2 and 35 years old and had a reported history of displaying problem behavior when presented with academic tasks.

Nick was a 17-year-old young man who attended high school. He was diagnosed with autism, mild to moderate ID, and disruptive behavior disorder. Nick's caregivers reported that his destructive problem behaviors were aggression (e.g., biting, hitting, pushing) and property destruction (e.g., tearing items, throwing items). Disruptive problem behavior was noncompliance (i.e., refusing to complete teacher directions) when presented with academic tasks in the classroom.

Ricky was an 8-year-old boy in the second grade. He was diagnosed with Tourette's syndrome, ADHD, and disruptive behavior disorder. Ricky's mother indicated that his destructive problem behaviors were aggression (e.g., hitting, kicking, biting), property destruction (e.g., tearing, throwing items), and inappropriate vocalizations (e.g., saying, "I hate you"). Disruptive problem behavior was noncompliance when Ricky was presented with academic demands.

Jalen was a 10-year-old boy in the fourth grade. Jalen was diagnosed with oppositional defiant disorder and attention deficit/hyperactivity disorder. His mother reported that destructive problem behavior was property destruction (e.g., tearing work tasks or drawing on work tasks). Disruptive problem behavior was noncompliance when presented with academic demands.

Setting and Materials

Experimental procedures were conducted in a clinic therapy room at the CDD (Nick) or at the participant's homes (Ricky and Jalen). Members of the research team conducted experimental sessions for 1 hr weekly for an average of 5.7 months (range, 4 to 8 months). An average number of 4.7 sessions were conducted during each weekly visit (range, 3 to 7). Each clinic therapy room contained a table and four chairs on one side of the room, and preferred activities were placed on a padded mat on the other side of the room. Therapy rooms were equipped with a ceiling-mounted video camera and microphone that permitted observations to be conducted from an adjacent room and video recording of experimental sessions. Ricky's and Jalen's sessions were conducted at a table in either the basement (Ricky) or kitchen (Jalen). A digital timer was used to signal the beginning and end of the experimental sessions.

Leisure Items

I used an MSWO preference assessment (DeLeon & Iwata, 1996) to identify relatively more-preferred, relatively medium-preferred, and relatively less-preferred tangible items. Tangible items used during Nick's analysis were raisins, iPad, dinosaurs, gears set, puzzles, and a cash register. Tangible items used during Ricky's analysis were ninjagos, cars, a fire truck, a football, and trios. Tangible items used during Jalen's analysis were a wooden dragon, stuffed animal, a Christmas ornament, a cross necklace, and cars.

Work Tasks

The work tasks were based on parent report of academic tasks that were (a) associated with problem behavior in the classroom or at home and (b) tasks that the participant could complete independently. Work tasks for Nick were fourth grade reading worksheets, fourth grade writing worksheets, triple-digit addition worksheets, and double-digit multiplication worksheets. Nick was allowed to use a calculator to complete math problems. Ricky was presented with second grade reading worksheets, second grade writing worksheets, and second grade math worksheets (double-digit addition). Jalen was presented with fourth grade reading worksheets, fourth grade writing worksheets, and fourth grade math worksheets (multiplication, division). For all participants, from five to 12 items were included on each worksheet.

Tokens

Participants had access to 18 total tokens, nine yellow and nine orange, over the course of the Experiment II. Each token was a square shape with a 5 cm x 5 cm circle drawn on the token. A black "+1" was drawn inside each circle. Yellow tokens were used to signal access to one reinforcer (i.e., raisins for Nick, ninjagos for Ricky, and stuffed animal for Jalen). Orange tokens were used to signal access to the other reinforcer (i.e., iPad for Nick, cars for Ricky, and the wooden dragon for Jalen).

Dependent Variables

Response Definitions

Data were collected on choice, problem behavior, and task completion. Choice was defined as making a vocal or gestural selection (e.g., pointing) toward one of two concurrently available choice options. Problem behavior was defined as destructive and disruptive behavior. Destructive problem behavior for Nick was defined aggression (e.g., hitting, pushing) and property destruction (e.g., tearing task materials, throwing task materials). Aggression was defined as Nick's hand forcefully coming into contact with the therapist or Nick using both hands to knock the therapist off balance. Property destruction was tearing work tasks and throwing work tasks off the table. Destructive problem behavior for Ricky was aggression (e.g., hitting, kicking, biting), property destruction (e.g., tearing task materials, slamming hands down on table), and negative vocalizations (e.g., saying, "I hate you"). Aggression was defined as Ricky's hands or foot forcefully coming into contact with the therapist or his mouth closing on the therapist's arm. Property destruction was defined as ripping work tasks or pounding his fists on the table. Negative vocalizations were defined as negative statements such as, "I hate you" or "I want to destroy you." Destructive problem behavior for Jalen was property destruction (e.g., slamming fists on table, drawing on work tasks). Property destruction was defined as drawing pictures on work tasks and tearing work tasks. Disruptive problem behavior for all three participants was defined as noncompliance (e.g., 3 s of not attending to or working on a task). Task completion was defined as completing all items on an individual worksheet. Leaving an item on a worksheet blank or engaging in destructive problem behavior while completing a task precluded task completion from being scored. Accuracy did not affect task completion.

Data Collection and Inter-Observer Agreement (IOA)

All sessions were digitally recorded using a handheld video recording device. Data were collected in vivo and via digital recordings. A 6-s partial-interval data recording system was used to code the data.

Choice data were collected during Phases 1 through 3 (i.e., MSWO preference assessment, concurrent operants assessment of play and work, and the unit price analysis). During the MSWO preference assessment, choice was recorded using an event-recording procedure. Each tangible item selected by the participants was recorded according to the order in which it was selected. For example, if Nick chose to play with the iPad first, this item was recorded as a "1." The last tangible item selected was recorded as a "6." For Nick, the identification of more, medium, and less preferred items selected for use in the concurrent operants assessment of work and play was the same as described in Experiment I. Because he allocated a majority of responding to work, another item was introduced (raisins). The raisins and a medium preferred item (iPad) were selected for use in the study. For Ricky and Jalen, the MSWO preference assessment was conducted at least three times before beginning the concurrent operants assessment of work and play. The order of selection for each item was added to identify the more, medium, and less preferred items. For example, if ninjagos were selected first during all four MSWO sessions, it would be assigned a value of four. Choice data during the concurrent operants assessment of play and work were recorded using an event-recording procedure. The choice between completing work alone or playing with a toy alone was recorded by noting which choice was made and was calculated as total frequency of choice responding. Choice data during the unit price analysis were recorded using an event-recording procedure. The choice between completing one of the two concurrently available choice options was recorded by noting which choice was made and was reported as which choice was made and not made.

Problem behavior data were collected using a 6-s partial-interval data recording system. Data recording sheets were divided into fifty 6-s intervals for each 5-min session. Problem behavior was reported as the combined percentage of intervals of destructive and disruptive problem behavior.

Task completion data were collected using an event-recording data collection system. Observers recorded when task completion occurred by placing a check mark above the 6-s interval on the 6-s partial-interval data recording system in which task completion occurred. Data on task completion were reported as frequency of task completion. Frequency of task completion was computed by adding the total number of tasks completed during each session.

IOA was completed by two independent observers for at least 30% of all sessions for each condition. IOA for choice and task completion was obtained via exact interval-by-interval comparisons of both observers' data across each of the dependent variables. An agreement was defined as both observers recording the same behavior in the same 6-s interval. A disagreement was defined as only one of the observers recording a behavior or as both observers recording different behaviors in the same 6-s interval. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and converting the result to a percentage. For Nick, IOA was 100% for choice, 99.9% (range, 96% to 100%) for task completion, and 99.9% (range, 98% - 100%) for problem behavior. For Ricky, IOA was 100% for choice, 98% (range, 89% to 100%) for task completion, and 99.7% (range, 93% to 100%) for problem behavior. For Jalen, IOA averaged 100% for choice, 97.8% (range, 90% to 100%) for task completion, and an average of 99.7% (range, 90% to 100%) for problem behavior.

Design and Analysis

Experiment II was conducted in seven phases. During Phase 1, I conducted an MSWO preference assessment within a concurrent schedules design. Each tangible item included during the MSWO preference assessment was available until it was selected, and then it was removed from the array of toys available. Selection was coded in a hierarchical manner, with the toys chosen first through fifth (Ricky and Jalen) or sixth (Nick) listed in the hierarchy. During Phase 2, the concurrent operants assessment of play and work was conducted according to the procedures described in Experiment I.

A unit price analysis of the play items selected in Phase 2 (Ricky) or a more preferred and medium preferred item (Nick) or more preferred and less preferred item (Jalen) was conducted within a concurrent schedules plus reversal design (Phase 3). Choices varied in terms of the amount of work that needed to be completed to obtain the reinforcers. The work amount was systematically increased until a break point was obtained. The break point was defined as the choice arrangement during which a participant’s choice making became variable or changed to the alternative choice. The choice arrangement preceding the break point was then re-implemented to show the potency of the reinforcer. Each choice was presented first or second and to the participant’s right or left sides equally across trials. Data for the unit price analysis were represented as choice allocation. Choice allocation was defined as the participant making a vocal or gestural (e.g., pointing) selection of one of the two available choice options.

Phases 4 (time contingent reinforcement analysis), 5 (positive reinforcement analysis), 6 (disruptor analysis), and 7 (reimplementation of treatment contingencies) were conducted in the same way as described in Experiment I.

Procedures

All procedures except those for Phase 3 (unit price) were the same as described for Experiment I. A unit price analysis was conducted immediately following the MSWO preference assessment. At the beginning of each session, the participant was directed to a table. The highest and lowest preferred items or activities the participant chose to engage with during Phase 2 were used during Phase 3. The first choice evaluated choice responding at a unit price of 1. Two copies of the same work task were presented to the participant. Directly above each task was a timer set to 1 min and the item to be earned after completing the task. The participant was told that he or she could choose to complete one task to earn 1 min of access to either item. After making a choice, the participant completed the work task by himself. No therapist attention was provided. If the participant refused to make a choice, a timer was set for 5 min, and at the end of 5 min the items were removed from the table and the next choice was presented. Problem behavior was placed on extinction. After the participants completed their tasks, they were presented with the item identified in Phase 1. The timer signaled the beginning and end of the play period. When the timer sounded, the procedures were repeated. Choices at a unit price of 1 continued to be presented until the participant chose the same item at least three consecutive times. Subsequent choices doubled the unit price and continued until the unit price was increased three consecutive times or the participant switched to the lower unit price. For example, the participant might have been asked to complete two tasks to earn 1 min of access to an item or one task to earn 1 min of access to the other item. If the participant continued to allocate responding to the choice requiring completion of two tasks for four consecutive choices, the work requirement was increased to four tasks for 1 min and then eight tasks for 1 min, if necessary. If the participants' choice responding changed such that they allocated responding to the reinforcer associated with the lower unit price for four consecutive choices, they were then presented with a choice at the previous unit price.

CHAPTER IV

RESULTS

The results for each participant in both Experiments 1 (Aida, Sarie, and Darren) and 2 (Nick, Ricky, and Jalen) are presented by experimental condition.

Experiment I Results

Concurrent Operants Assessment of Play and Work

A concurrent operants assessment of play (with low-preferred [LP], medium-preferred [MP], and high-preferred [HP] items) and work was conducted to show the conditions under which each participant chose to escape a work task in favor of engaging with a leisure activity. Aida (Figure 2, top panel) showed choice allocation away from work only when the HP item was available. She allocated exclusively to work on six of seven sessions when the alternative option was an LP item or MP item. Conversely, she allocated exclusively to the HP item during five of the seven sessions. Sarie and Darren (Figure 2, middle and bottom panels, respectively) showed choice allocation away from work during all three sessions when the LP item was concurrently available.

Time Contingent Reinforcement Phase

The time contingent reinforcement phase showed no systematic differences in frequency of task completion for any of the participants. Aida's task completion (Figure 3, top panel) was initially stable across both stimulus conditions with both showing an increasing trend during the final three sessions. Average task completion for the yellow stimulus was 4.5 (range, 2.0 tasks to 7.0 tasks) tasks and was 4.0 (range, 3.0 tasks to 7.0 tasks) tasks for the orange stimulus. Problem behavior (Figure 3, bottom panel) was initially high but decreased towards the end of this analysis for both the orange (M = 52%; range, 4% to 70%) and the yellow (M = 36%; range, 2% to 76%) stimulus conditions. Sarie's task completion (Figure 4, top panel) showed an increasing trend for each stimulus condition. Average task completion for the yellow stimulus was 6.3 (range, 3.0 tasks to 9.0 tasks) tasks and was 5.5 (range, 1.0 task to 9.0 tasks) tasks for the orange stimulus. Problem behavior (Figure 4, bottom panel) occurred at low levels for both stimulus conditions. Problem behavior occurred for an average of 9.3% (range, 0% to 36%) of intervals for the orange stimulus condition and for an average of 1.7% (range, 0% to 6%) of intervals for the yellow stimulus. Darren's task completion (Figure 5, top panel) was variable but showed a decreasing trend across sessions. Average task completion for both the yellow and the orange stimuli was 3.6 (range, 0 tasks to 9.0 tasks). Problem behavior (Figure 5, bottom panel) was similarly variable during this phase. Problem behavior occurred for an average of 63.6% (range, 0% to 100%) of intervals for the orange stimulus and for an average of 62.3% (range, 0% to 100%) for the yellow stimulus.

Positive Reinforcement Phase

The positive reinforcement phase resulted in similar rates of reinforcement for each stimulus condition for each participant. Aida (Figure 3, top middle panel) showed similar levels of consistent task completion for both the orange (M = 7.44 tasks completed; range, 3.0 tasks to 9.0 tasks) and the yellow stimuli (M = 7.0 task completed; range, 4.0 tasks to 9.0 tasks). These mean frequencies were higher than the previous phase. Problem behavior (Figure 3, bottom panel) was exhibited at low levels throughout this phase. Problem behavior for the orange stimulus occurred for an average of 12% (range, 0% to 12%) of intervals and for an average of 10% (range, 0% to 52%) for the yellow stimulus. Sarie's (Figure 4, top panel) task completion was initially on a moderate upward trend for both stimuli before becoming relatively stable for both stimuli. Task completion for the orange stimulus averaged 7.1 (range, 6.0 tasks to 9.0 tasks) and averaged 7.0 (range, 4.0 tasks to 9.0 tasks) tasks completed for the yellow stimulus. These mean frequencies were higher than the previous phase. Problem behavior (Figure 4, bottom panel) did not occur under either stimulus condition. Darren's (Figure 5, top panel) task completion was variable before becoming consistent over the last eight sessions. Task completion for the orange stimulus averaged 6.1 (range, 0 tasks to 9.0

tasks) tasks completed and 4.9 (range, 0 tasks to 9.0 tasks) tasks completed for the yellow stimulus. The average frequency of task completion for the last four sessions of each stimulus condition was 8.8 tasks completed. These mean frequencies were higher than the previous phase. Problem behavior (Figure 5, bottom panel) was initially variable but remained low and steady during the final three sessions for both the orange (*M* = 32.6%; range, 0% to 100%) and the yellow (*M* = 41.5%; range, 0% to 100%) stimulus conditions.

Concurrent Operants Assessment of Tangible Items and Attention

The concurrent operants assessment of tangible items and attention showed a relative preference for tangible items for Aida and Sarie (Figure 6, top and middle panels, respectively). Aida allocated an average of 97.6% (range, 90% to 100%) of each session to the tangible items, and Sarie allocated 100% of her time to the tangible items. Darren (Figure 6, bottom panel) did not show a preference. Darren allocated an average of 51% (range, 0% to 100%) of each session to the tangible items and an average of 50% (range, 0% to 100%) to attention.

Disruptor Phase

The disruptor phase showed modest differences in the persistence of task completion for Aida and Sarie (Figures 3 and 4, top right hand panels, respectively), but these differences were consistent with their preference. Task completion was initially high for both stimuli and decreased to near zero levels within three sessions for Aida. Aida completed an average of 5.3 (range, 1.0 task to 9.0 tasks) tasks for the orange stimulus and an average of 3.0 (range, 1.0 task to 7.0 tasks) tasks for the yellow stimulus. Aida's proportion of baseline data showed a similar pattern (Figure 7, top panel). Problem behavior showed resurgence under both the orange (*M* = 33%; range, 0% to 84%) and the yellow stimulus conditions (*M* = 60%; range, 4% to 92%). Task completion remained high for Sarie (Figure 4, top panel) throughout this condition with slight differences occurring in the levels of task completion during the final four sessions of this condition. Sarie completed an average of 8.5 tasks (range, 7.0 tasks – 9.0 tasks) for the orange stimulus and 8.1 tasks (range, 5.0 tasks – 9.0 tasks) for the yellow stimulus. Sarie's proportion of baseline data (Figure 7, middle panel) showed a similar pattern. Problem behavior (Figure 4, bottom panel) was initially low but increased towards the end of the disruptor analysis. Problem behavior was observed for an average of 18.1% (range, 0% - 70%) for the yellow stimulus condition and for an average of 18.4% (range, 0% - 68%) for the orange stimulus condition. There were no consistent differences in task completion during this condition for Darren (Figure 5, top panel). Task completion was variable for both stimuli and eventually became consistent and steady at the end of this condition. Task completion for the orange stimulus averaged 6.1 (range, 0 to 9.0 tasks) tasks completed and 5.1 (range, 0 to 9.0 tasks) tasks completed for the yellow stimulus. Darren's proportion of baseline data (Figure 7, bottom panel) showed greater persistence of task completion for the stimulus context associated with the delivery of tangibles (orange). The high amount of variability in task completion during the positive reinforcement analysis resulted in discrepant levels of task completion, and thus, the proportion of baseline data is different from the task completion data. Behavioral persistence research has varied in the number of sessions included in the calculation of proportion of baseline. Some studies have included all sessions prior to the disruptor condition (Mace et al., 2010) and others have used the last three to five sessions prior to the disruptor condition (Grimes & Shull, 2001; Nevin et al., 1983). In this study, an analysis of proportion of baseline was conducted using the last four data points from each stimulus condition because they represented steady state responding. Proportion of baseline looked similar between the stimulus conditions when using this analysis (Figure 8). Average proportion for the orange stimulus was 0.69 and was 0.59 for the yellow stimulus. Problem behavior (Figure 5, bottom panel) was initially variable but ended at low and steady levels for both stimulus conditions. Average problem behavior under the orange stimulus was 46.9% (range, 0% to 100%) and under the yellow stimulus was 42.4% (range, 0% to 100%).

Re-Implementation of Treatment Contingencies

Treatment was not re-implemented for Aida because she transitioned into another study targeting compliance with work tasks. Task completion was high at the end of the disruptor analysis for Sarie and Darren and remained high after treatment was re-implemented. Sarie completed 8 tasks and Darren completed 9 tasks during this phase. No problem behavior occurred.

Overall, then, minor differences occurred for Aida and Sarie. For both participants, task completion persisted slightly longer in the stimulus condition associated with the more preferred reinforcer. Darren did not show a difference in the persistence of task completion; however, one was not expected given that no relative preference was identified.

One reason for these effects may have been the relative level of preference for tangibles and attention. Research has shown that reinforcers can vary in their potency, meaning that reinforcers can differentially maintain responding at higher response requirements (DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994). Each of these studies showed that under low response requirements, two stimuli may function equally as reinforcers. This may not be the case at higher response requirements, and, actually, one stimulus may maintain responding at a higher response requirement than the other. Experiment I evaluated preference under low response requirements (i.e., participants needed to walk to different sides of the room), thus it is unclear if tangibles and attention were similarly potent reinforcers. If so, this would account for the only minor differences obtained from Experiment I. To further analyze this possibility, I conducted Experiment II to evaluate the effect of reinforcer potency on the persistence of task completion.

Experiment II Results

Multiple Stimulus Without Replacement (MSWO)

Preference Assessment

The MSWO preference assessment identified HP, MP, and LP items for all three participants. Nick's (Figure 9, top panel) HP item was raisins followed by dinosaurs, a toy cash register, an iPad, a gears set, and a puzzle. Ricky's (Figure 9, middle panel) HP item was ninjagos. Balls and cars were identified as being MP items, and a fire truck and trios were identified as LP items. Jalen's (Figure 9, bottom panel) HP item was a wooden dragon. The minion Christmas ornament and cars were MP items, and the stuffed animal and cross necklace were the LP items.

Concurrent Operants Assessment of Play and Work

Nick (Figure 10, top panel) allocated the majority of his choices to work when the LP, MP, and HP items were concurrently available. Ricky's (Figure 10, middle panel) choice allocation for work and play was variable when the LP item was available. He allocated the majority of choice responding away from work when the MP and HP items were available. Jalen (Figure 10, bottom panel), like Nick, allocated the majority of his choice responding to work when the LP, MP, and HP items were concurrently available.

Unit Price Analysis

The unit price analysis was conducted to evaluate reinforcer potency for the HP and LP items (Nick and Jalen) and the MP and HP items for Ricky. Raisins were shown to be twice as potent as iPad for Nick (Figure 11, top panel). Nick allocated exclusive choice responding to raisins when both raisins and iPad were available at a unit price (UP) of 1. Choice responding continued to be directed toward raisins when they were available at a UP of 2 and iPad was available at a UP of 1. Nick's choice responding became variable when raisins were available at a UP of 4. A reversal to having raisins available at a UP of 2 and again at a UP of 4 replicated these data.

Ninjagos were shown to be slightly more potent than cars for Ricky (Figure 11, middle panel). When ninjagos and cars were available at a UP of 1, Ricky initially allocated choice responding to the cars. He allocated to ninjagos during the next choice arrangement when cars were available at a UP of 2 and ninjagos were available at a UP of 1. He continued to allocate to the ninjagos when both were available at a UP of 1. Choice responding switched to cars when ninjagos were available at a UP of 2 but returned to ninjagos when they were both available at the UP of 1 again. A final return to having ninjagos available at a UP of 2 replicated these data.

The stuffed animal was shown to be slightly more potent than the dragon for Jalen (Figure 11, bottom panel). Jalen allocated exclusively to the stuffed animal when it and the dragon were available at a UP of 1. He then began allocating to the dragon when the stuffed animal was available at a UP of 2. A reversal back to having the stuffed animal available at a UP of 1 and a UP of 2 replicated these data.

Time Contingent Reinforcement Phase

Task completion during the time contingent reinforcement analysis for Nick (Figure 12, top panel) was stable for both stimulus conditions. Task completion for the orange stimulus averaged 4.6 (range, 4.0 to 6.0 tasks) tasks completed and 4.8 (range, 4.0 to 6.0 tasks) tasks completed for the yellow stimulus. Problem behavior (Figure 12, bottom panel) did not occur. Ricky showed initially high levels of task completion (Figure 13, top panel), which decreased over time. For both stimulus conditions, task completion for the orange stimulus averaged 5.0 (range, 3.0 to 7.0) tasks completed and averaged 5.7 (range, 2.0 to 9.0) task completed for the yellow stimulus. Problem behavior (Figure 13, bottom panel) was on an increasing trend for both the yellow (*M* = 41.3%; range, 0% to 76%) and the orange (*M* = 46.7%; range, 6% to 72%) stimulus conditions. Jalen also showed initially high levels of task completion that decreased over time (Figure 14, top panel). Task completion for the yellow stimulus averaged 2.5 (range, 1.0 to 6.0 tasks) tasks completed and averaged 2.0 (range, 1.0 to 4.0 tasks) tasks completed for the orange stimulus. Problem behavior (Figure 14, bottom panel) was on an increasing trend for both the orange (*M* =65%; range, 28% to 90%) and the yellow (*M* = 64%; range, 12% to 84%) stimulus conditions.

Positive Reinforcement Phase

Task completion was slightly variable for Nick (Figure 12, top panel) but showed a modest increase across sessions. There was no difference in task completion between the time contingent reinforcement and positive reinforcement analyses. Task completion for the orange stimulus occurred at a mean frequency of 3.9 (range, 2 to 6) and at a mean frequency of 4.3 (range, 3 to 6) for the yellow stimulus. Problem behavior (Figure 12, bottom panel) was low for both the orange (*M* = 4.9%; range, 0% to 40%) and the yellow stimulus (*M* = 1%; range, 0% to 10%) conditions. Ricky's task completion (Figure 13, top panel) increased over the time contingent reinforcement analysis and remained steady for both stimulus conditions. Mean level of task completion was 8.6 for both stimulus conditions. Problem behavior (Figure 13, bottom panel) remained low during this analysis. Mean level of problem behavior for the yellow stimulus was 2.4% (range, 0% - 12%) and for the orange stimulus was 1.6% (range, 0% to 8%). Jalen also showed an increase in task completion (Figure 14, top panel) over the time contingent reinforcement analysis for both stimulus conditions. Mean level of task completion for the orange stimulus was 5.5 (range, 3 to 7) and for the yellow stimulus was 5.9 (range, 5 to 6). Problem behavior (Figure 14, bottom panel) remained low and averaged 19.4 (range, 0% to 46%) for the orange stimulus and 14.8% (range, 0% to 34%) for the yellow stimulus.

Disruptor Phase

There was no difference in the frequency of task completion between the two stimulus conditions for Nick. Task completion (Figure 12, top panel) was initially low for the orange stimulus (*M* = 2.9; range, 0 to 6), then recovered, and finally decreased to zero after five sessions. Task completion for the yellow stimulus (*M* = 3.9; range, 0 to 6) was initially high but decreased to zero after six sessions. Proportion of baseline data (Figure

15, top panel) showed a modest difference between the yellow (more potent) and orange (less potent) stimulus conditions. Task completion persisted longer under the stimulus condition associated with the less potent reinforcer. Average proportion of baseline for the yellow stimulus was 0.90 (range, 0 – 1.4) and was 0.74 (range, 0 – 1.54) for the orange stimulus. Problem behavior (Figure 12, bottom panel) increased as task completion decreased for both the orange (*M* = 50%; range, 0% to 100%) and the yellow (*M* = 27%; range, 0% to 100%) stimulus conditions.

Ricky showed greater persistence of task completion (Figure 13, top panel) under the stimulus condition associated with the more potent reinforcer. Task completion for the yellow stimulus condition showed a slight decreasing trend before stabilizing at the end of this condition. Task completion occurred for an average of 7.25 (range, 5 to 8) during the yellow stimulus condition. Task completion for the orange stimulus showed a more steep decreasing trend at the end of this condition and decreased to near zero levels. Task completion for the orange stimulus condition occurred for an average of 6 (range, 1 to 9). Proportion of baseline data (Figure 15, middle panel) showed a similar pattern for both stimulus conditions. The yellow stimulus condition (*M* = 0.84; range, 0.58 to 0.93) showed greater persistence than the orange stimulus condition (*M* = 0.69; range, 0.12 to 1.0). Problem behavior (Figure 13, bottom panel) was initially low for both stimulus conditions. Variability in problem behavior emerged towards the end of the disruptor analysis for the yellow stimulus (*M* = 11.3%; range, 0% to 50%), and was on an increasing trend for the orange stimulus (*M* = 18%; range, 0% to 72%).

Task completion (Figure 14, top panel) showed a clear effect for persistence of task completion consistent with the studies' hypothesis at the end of this phase for Jalen. Task completion for the yellow stimulus was variable before steadily decreasing to near zero levels (*M* = 4.1; range, 1 to 7). Task completion for the orange stimulus was also variable before decreasing to zero (*M* = 3.8; range, 0 to 7). Task completion for the yellow, more potent, stimulus persisted longer than task completion for the orange, less potent, stimulus. Proportion of baseline (Figure 15, bottom panel) data showed a similar pattern for the yellow (*M* = 0.69; range, 0.17 to 1.2) and orange (*M* = 0.69; range, 0 to 1.1) stimulus conditions. Problem behavior (Figure 14, bottom panel) was variable for both stimulus conditions. Variability in problem behavior was observed for both the orange (*M* = 46.4%; range, 4% to 100%) and yellow (*M* =37.9%; range, 12% to 76%) stimulus conditions.

Re-Implementation of Treatment Contingencies

Treatment was not re-implemented for Nick due to scheduling conflicts. Treatment was described for his mother by telephone instead. Ricky completed eight tasks during each of two treatment sessions, and problem behavior was low (*M* = 3%; range, 2% - 4%) during these sessions. Task completion was on an increasing trend and problem behavior was on a decreasing trend during two treatment sessions for Jalen. He initially completed two tasks and engaged in problem behavior during 42% of the session. Five tasks were completed during the second treatment session and problem behavior decreased to 26% of the session.

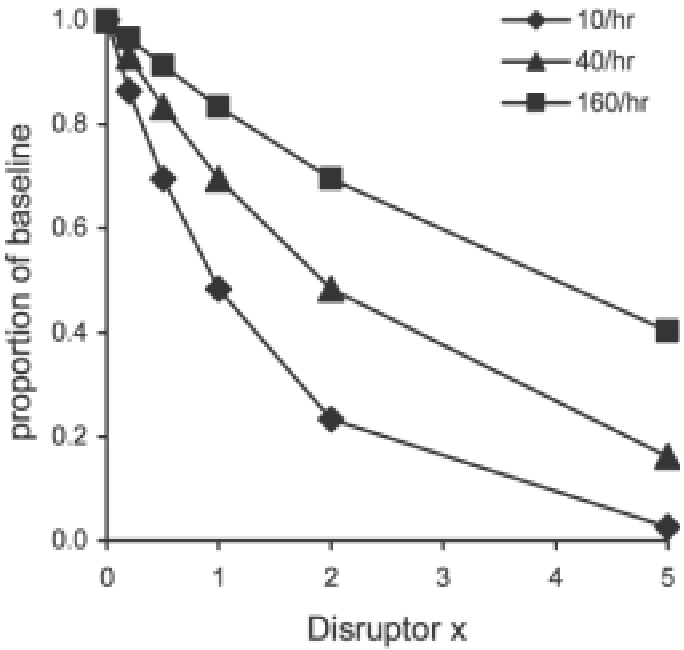

Figure 1. Shows the effect of disruptor (x) when rate of reinforcement varies. Shows the direct relationship between rate of reinforcement and persistence.

Source: Nevin, J. A. & Shahan, T. A. (2011). Behavioral momentum theory: Equations and applications. *Journal of Applied Behavior Analysis, 44,* 877-895. doi: 10.1901/jaba.2011.44-877

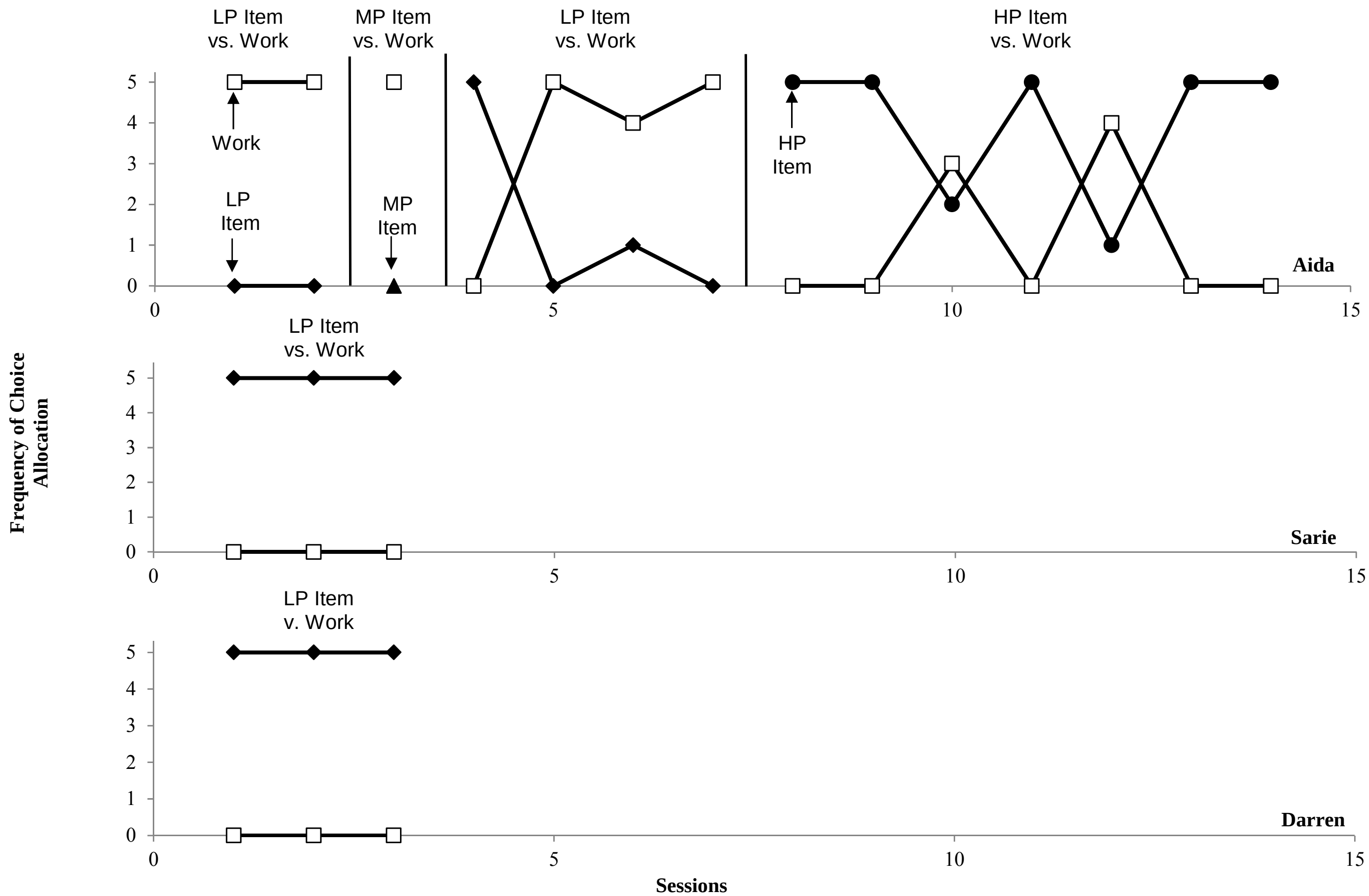

Figure 2. Concurrent operants assessment of play and work for Aida (top panel), Sarie (middle panel), and Darren (bottom panel). The open squares represent a choice to work, closed diamonds represent a choice to play with the LP item, the closed triangle represents a choice to play with the MP item, and the closed circle represents a choice to play with the HP item.

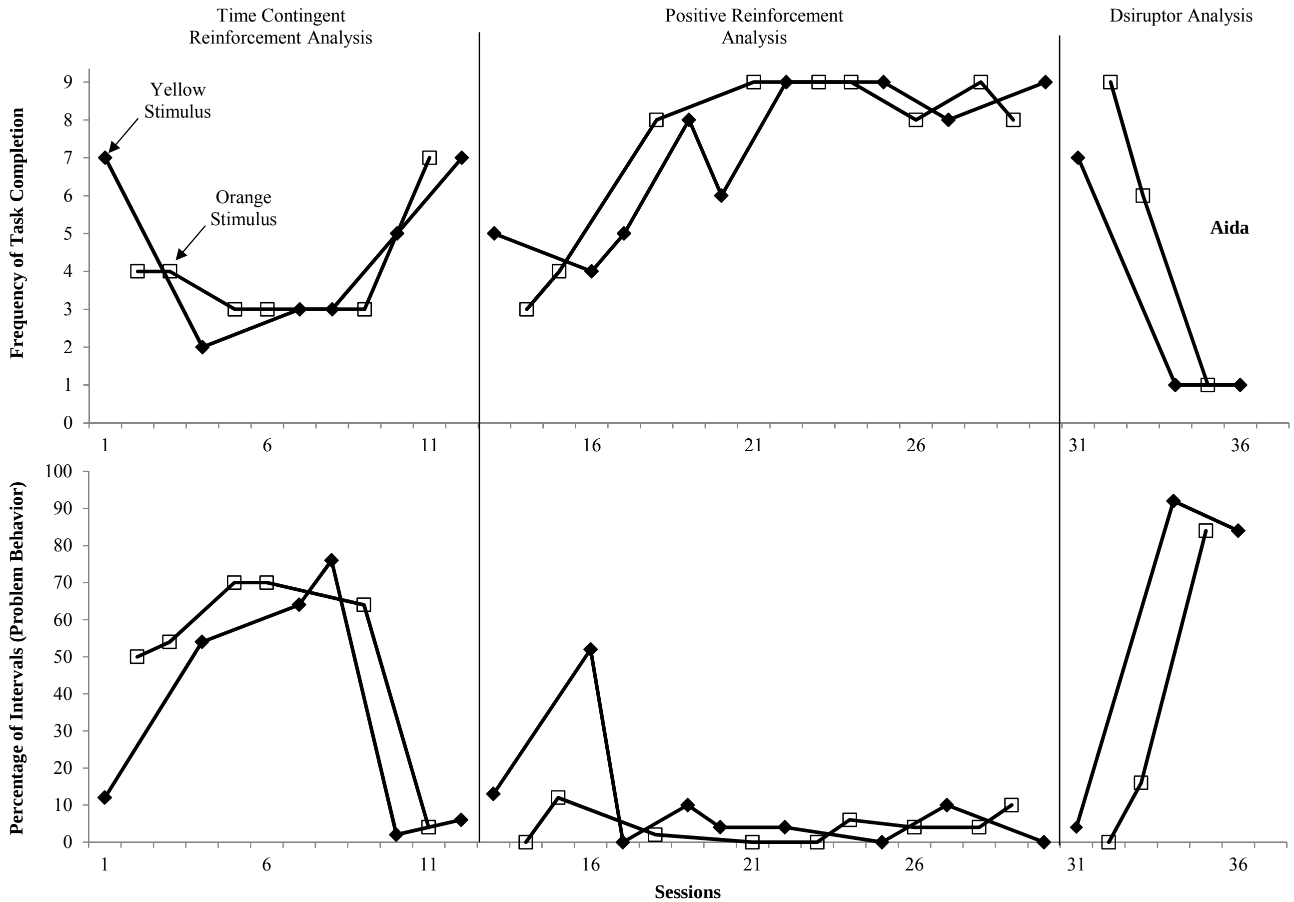

Figure 3. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Aida. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent the orange stimulus and the closed diamonds represent the yellow stimulus.

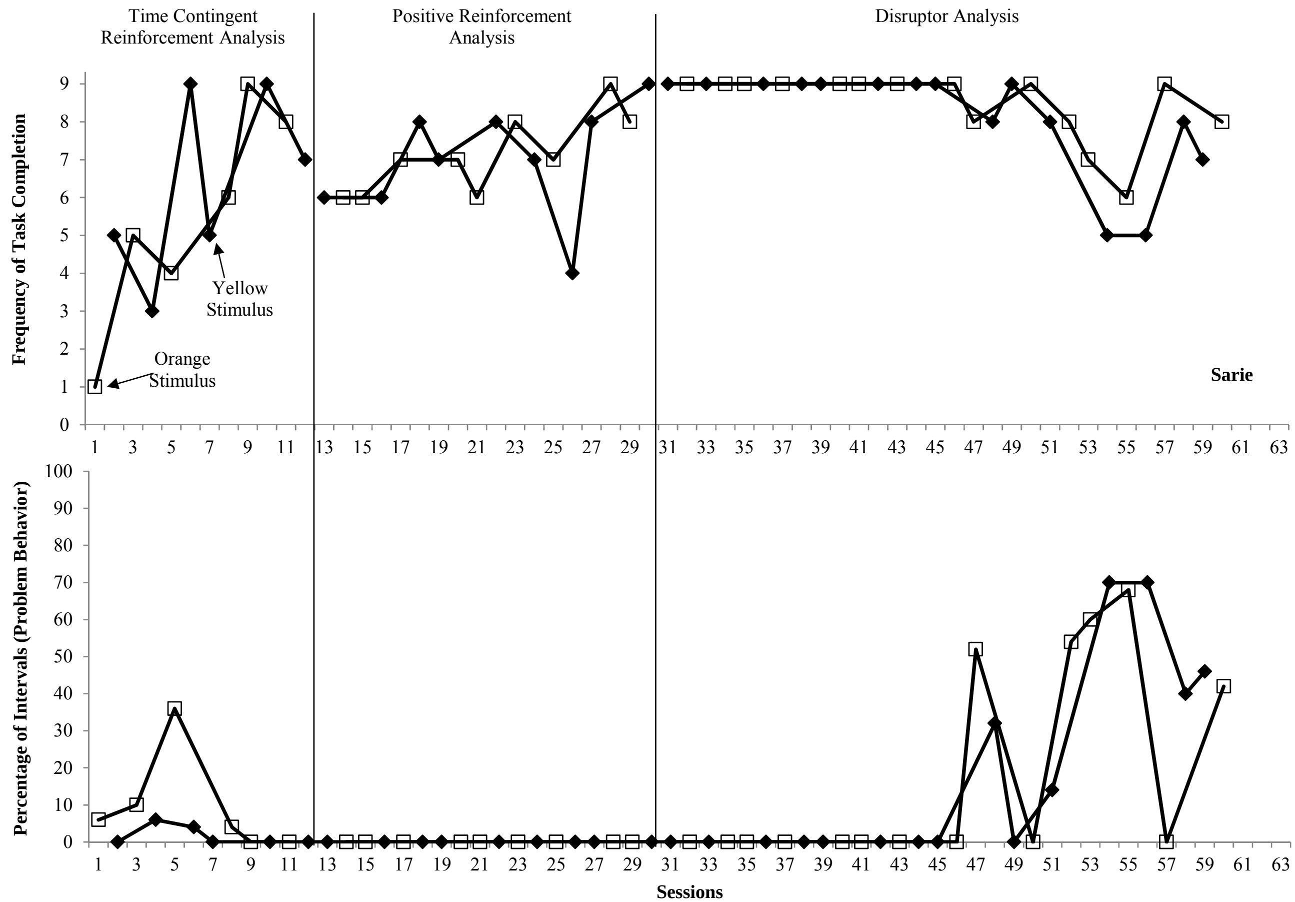

Figure 4. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Sarie. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent the orange stimulus and the closed diamonds represent the yellow stimulus.

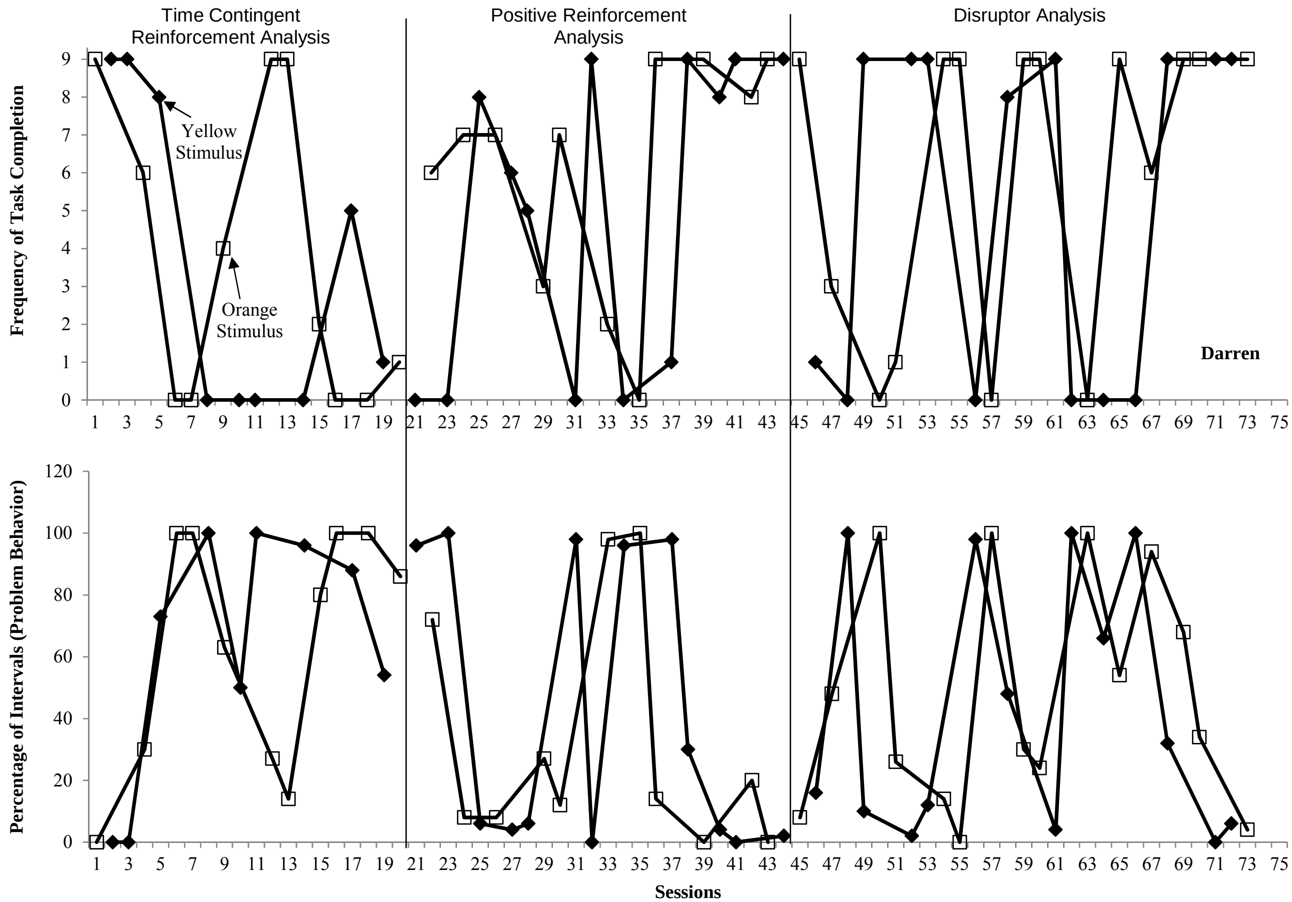

Figure 5. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Darren. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent the orange stimulus and the closed diamonds represent the yellow stimulus.

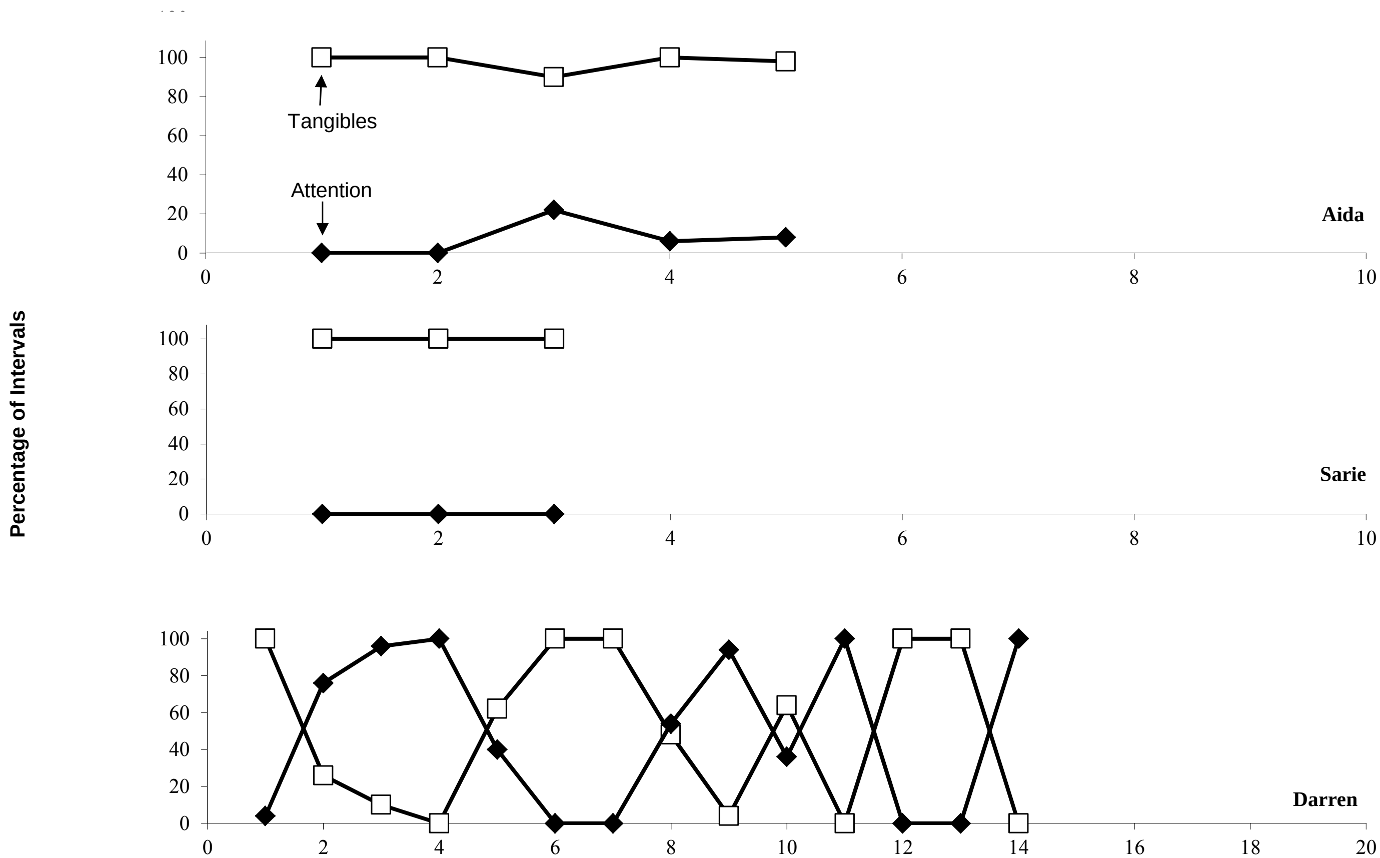

Figure 6. Data from the concurrent operants assessment of attention and tangibles for Aida (top panel), Sarie (middle panel), and Darren (bottom panel). Data are presented as percentage of intervals. Closed diamonds represent choice allocation to attention and the open squares represent choice allocation to tangibles.

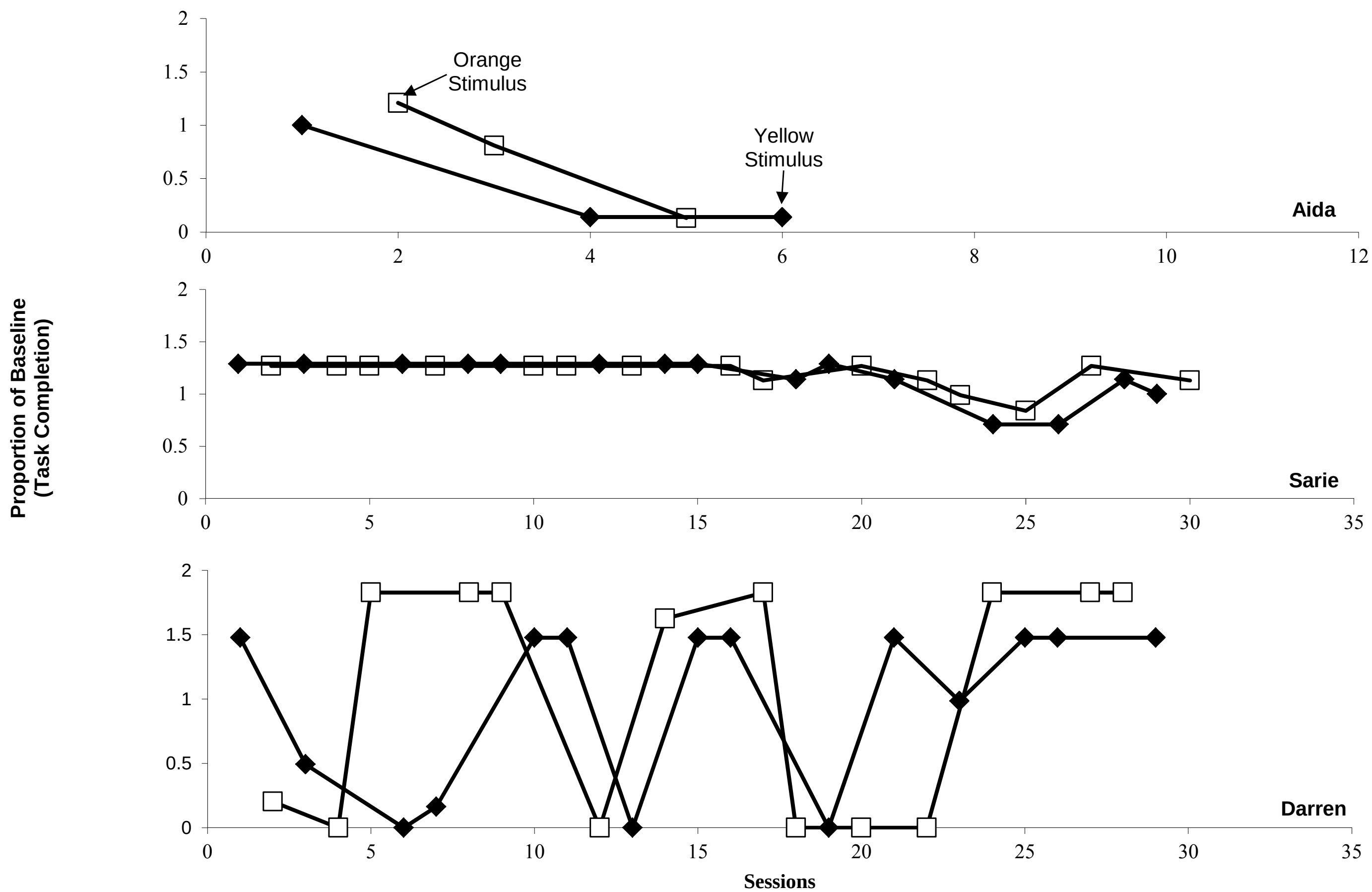

Figure 7. Proportion of baseline for task completion for Aida (top panel), Sarie (middle panel), and Darren (bottom panel). Closed diamonds represent proportional responding for the yellow stimulus condition. Open squares represent proportional responding for the orange stimulus condition.

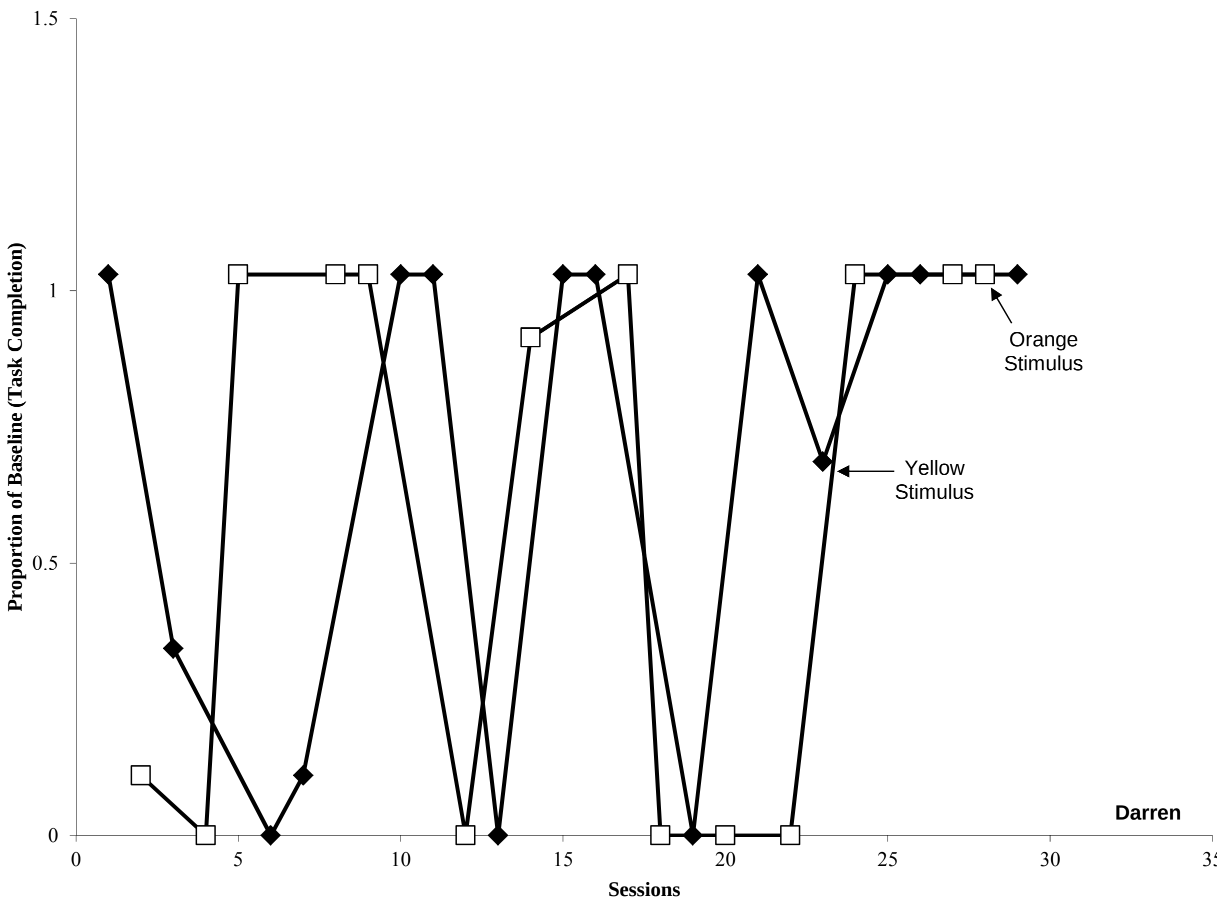

Figure 8. Proportion of baseline for the last four sessions of each stimulus condition for Darren. Closed diamonds represent responding under the yellow stimulus condition. Open squares represent responding under the orange stimulus condition.

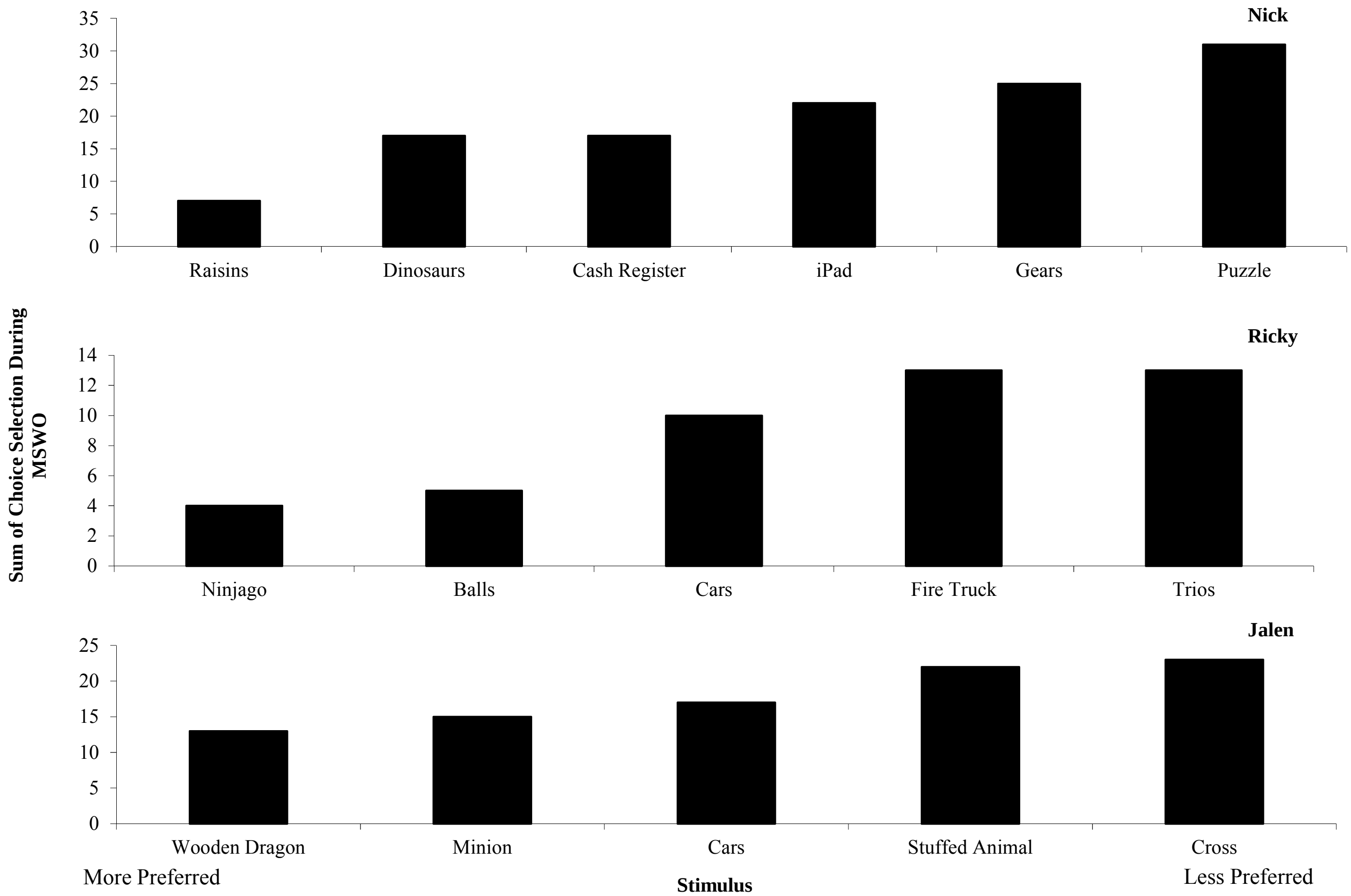

Figure 9. MSWO preference assessment data for Nick (top panel), Ricky (middle panel), and Jalen (bottom panel).

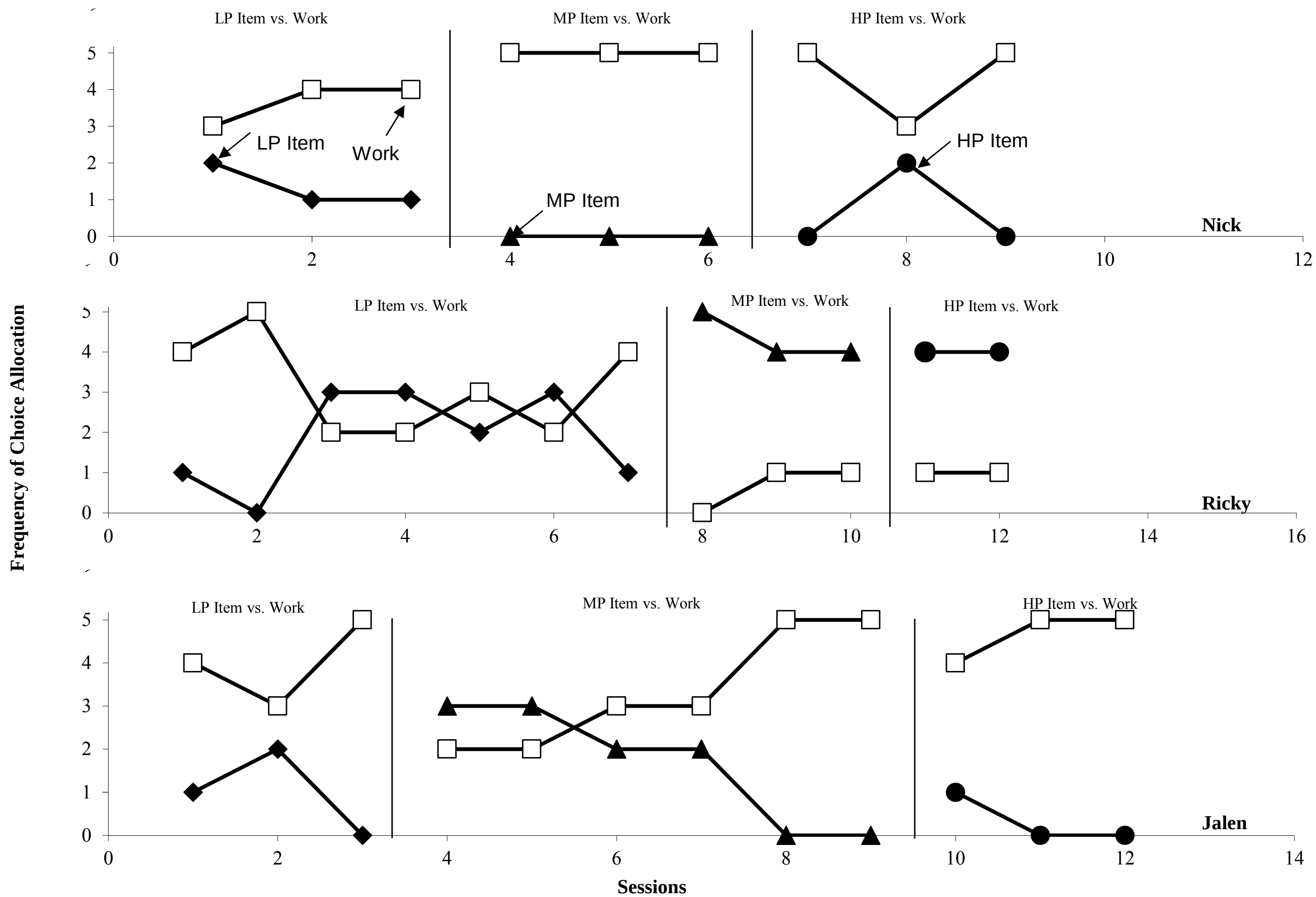

Figure 10. Concurrent operants assessment of play and work for Nick (top panel), Ricky (middle panel), and Jalen (bottom panel). The open squares represent a choice to work, closed diamonds represent a choice to play with the LP item, the closed triangle represents a choice to play with the MP item, and the closed circle represents a choice to play with the HP item.

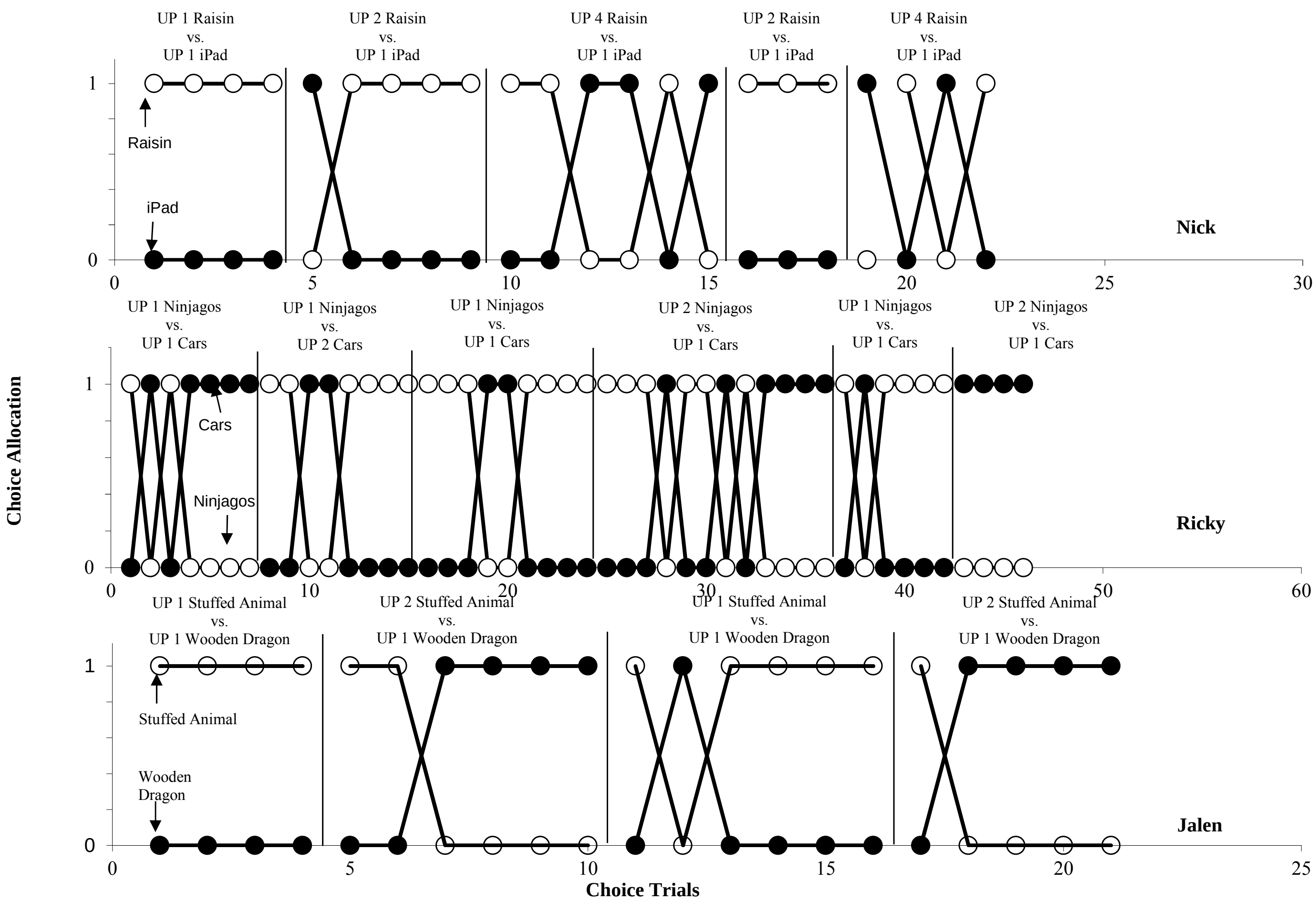

Figure 11. Unit price analysis for Nick (top panel), Ricky (middle panel), and Jalen (bottom panel). The stimulus shown to be the more potent reinforcer is represented by the open circles. The stimulus shown to be the less potent reinforcer is represented by the closed circles.

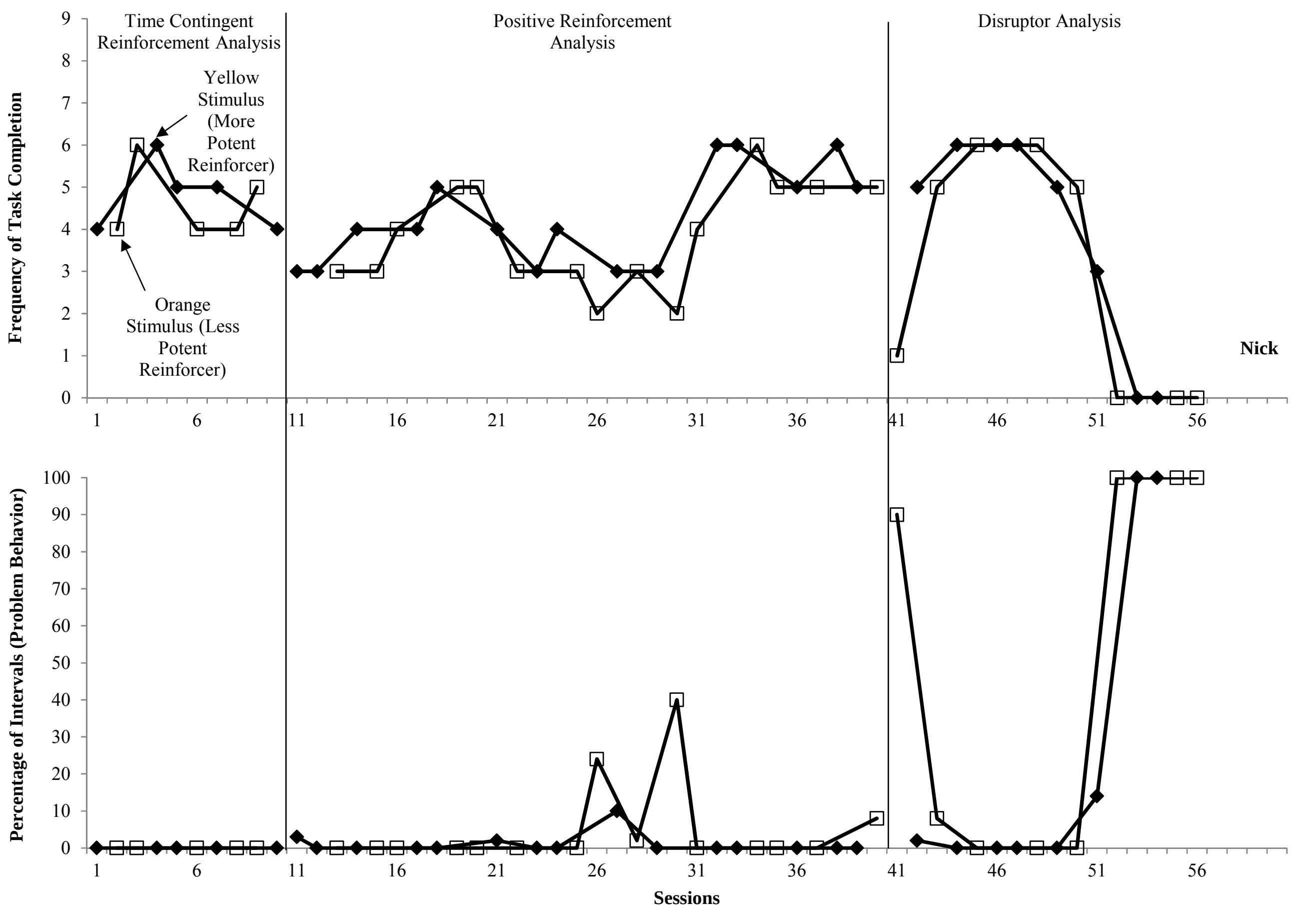

Figure 12. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Nick. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent sessions for the orange stimulus condition (less potent reinforcer) and the closed diamonds represent sessions for the yellow stimulus condition (more potent reinforcer).

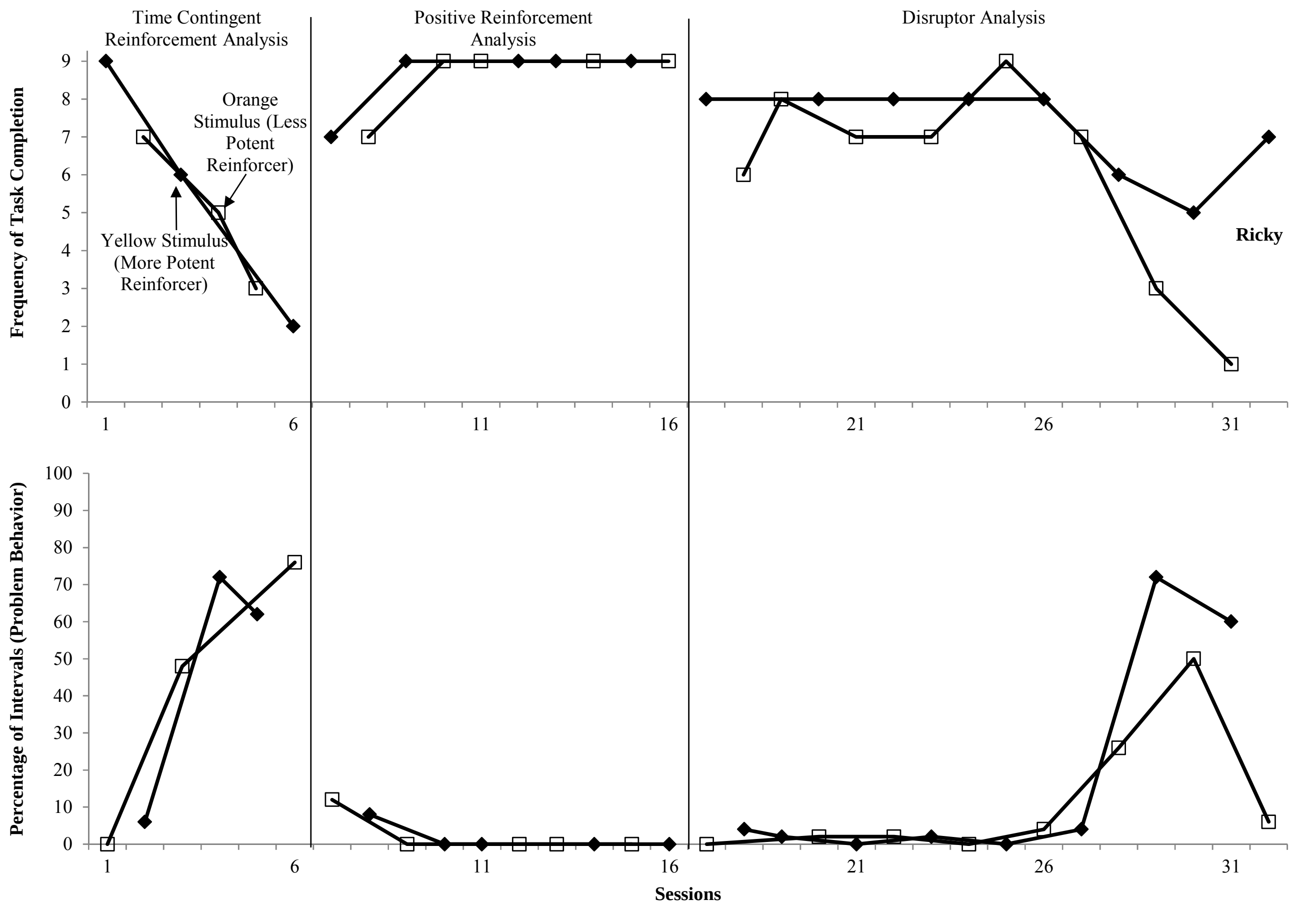

Figure 13. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Ricky. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent sessions for the orange stimulus condition (less potent reinforcer) and the closed diamonds represent sessions for the yellow stimulus condition (more potent reinforcer).

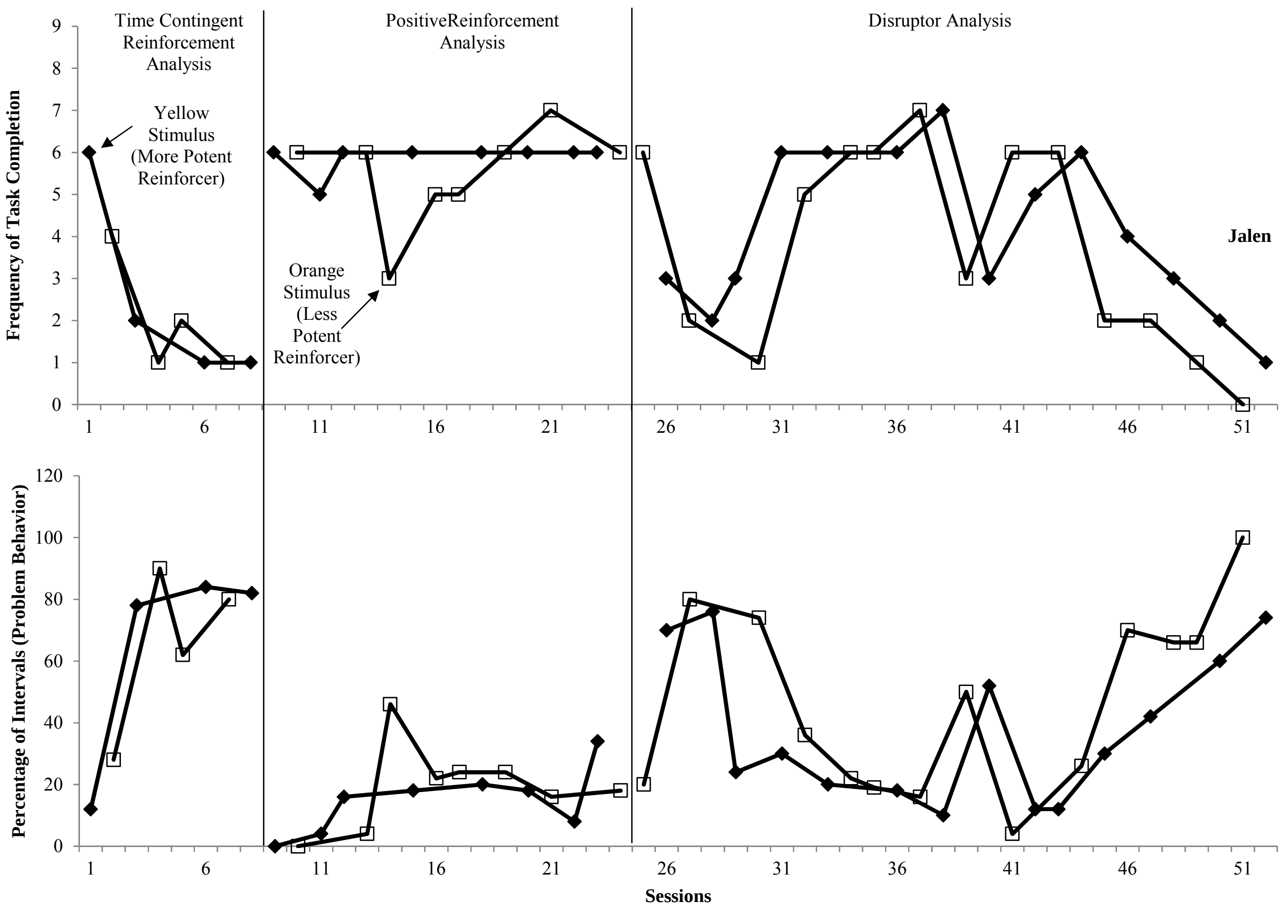

Figure 14. Data from the time contingent reinforcement analysis (left panel), positive reinforcement analysis (middle panel), and disruptor analysis (right panel) for Jalen. The top panel represents task completion and the bottom panel represents percentage of intervals of problem behavior. Open squares represent sessions for the orange stimulus condition (less potent reinforcer) and the closed diamonds represent sessions for the yellow stimulus condition (more potent reinforcer).

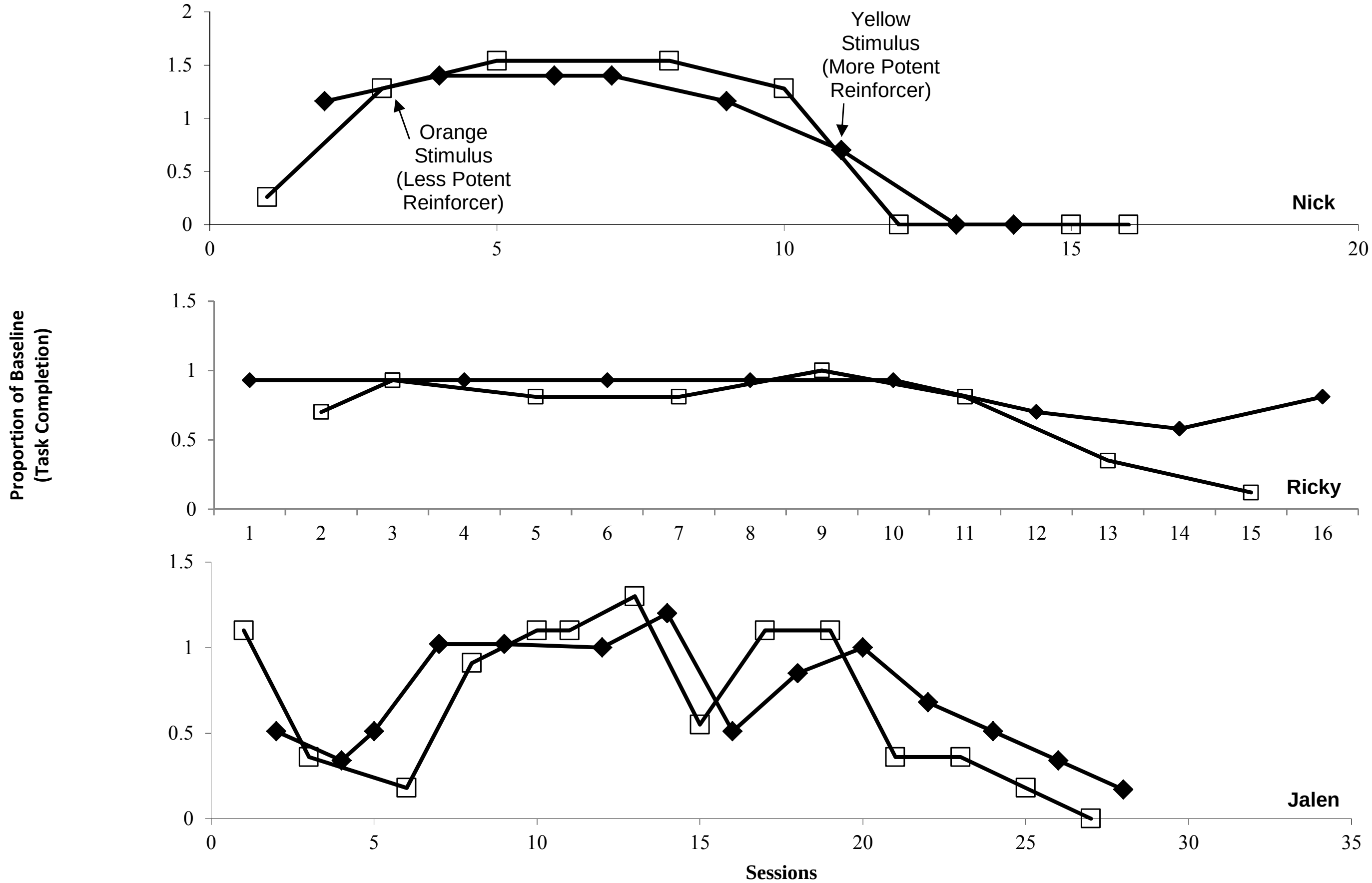

Figure 15. Proportion of baseline for task completion for Nick (top panel), Ricky (middle panel), and Jalen (bottom panel). Open squares represent proportion of baseline task completion for the orange stimulus condition (less potent reinforcer), and the closed diamonds represent proportion of baseline task completion for the yellow stimulus condition (more potent reinforcer).

CHAPTER V

DISCUSSION

Maintenance has most often been defined as steady state responding under the prevailing conditions of treatment (e.g., Stokes & Baer, 1977). One translation of the theory of behavioral momentum has defined maintenance as the persistence of appropriate behaviors during challenges to treatment (Nevin & Wacker, 2013). Thus, maintenance occurs when the appropriate behavior targeted during treatment persists in spite of challenges to the treatment, such as extinction (Mace et al., 2010; Wacker et al., 2011) or distraction (Mace et al., 1990). Although these initial translations have been successful, much more applied research is needed on how to best increase the persistence of appropriate behavior (Dube et al., 2009).

To date, research with humans has focused almost exclusively on the effects of rate of reinforcement on the persistence of target behavior (Mace et al., 2010; Parry-Cruwys et al., 2011; Romani et al., 2013). Very little research has evaluated the effects of any other dimension of reinforcement on persistence (Mace et al., 1997). Thus, the purpose of my dissertation was to evaluate the effects of a different dimension of reinforcement, quality, on the persistence of task completion for individuals who engaged in problem behavior to escape from academic demands. Experiment I evaluated the effects of preference for class of reinforcement (attention or tangibles) on the persistence of task completion. I hypothesized that greater persistence of task completion would occur under the multiple schedules component associated with the delivery of the more preferred class of reinforcement. I based this hypothesis on previous studies of quality that showed that this dimension of reinforcement could affect responding on academic tasks even more than rate of reinforcement (Neef et al., 1994) and could increase persistence in nonhuman subjects (Mace et al., 1997).

The results from Experiment I showed only modest effects, but they were consistent with this hypothesis. Aida and Sarie showed greater persistence of task completion within the stimulus context associated with the delivery of the higher preferred reinforcer (tangibles). Darren did not show a preference for attention or tangibles and also did not show differences in persistence of task completion. Although positive, these effects were less than what had previously been shown for rate of reinforcement (Nevin, 1974; Nevin et al., 1983).

There are at least three potential explanations for why quality of reinforcement had only modest effects on persistence in Experiment I. First, stimuli serving as reinforcers under low response requirements may not function as reinforcers following increases to response requirements (DeLeon, Iwata, Goh, & Worsdell, 1997; Roane et al., 2001; Tustin, 1994). Stimuli that function as reinforcers under both high and low response requirements are described as being potent (Roane, 2008). Because the relative potency of attention and tangibles was not assessed, it is unclear if either of these classes of reinforcement was more potent. Attention and tangibles could have been similarly potent reinforcers and thus did not differentially strengthen task completion. It is also possible that neither class was a potent reinforcer and thus had only modest effects on persistence.

Second, during the course of the current study, the participants were presented with the same work tasks by the same experimenter, who also played with the participants during breaks. Research has shown that completing the tasks themselves can persist even in the absence of reinforcement (Wacker et al., 2011). Several of the participants in the Wacker et al. (2011) study showed persistence of task completion before they showed persistent treatment effects for problem behavior. It is possible that during DRA treatment participants learned that the tasks were not aversive; that is, the motivating operations (MO) to escape the tasks may have been abolished. Relatedly, the repeated pairings of the experimenter delivering tokens for task completion and then engaging with the participant during the reinforcement interval could have conditioned experimenter attention as a reinforcer.

Third, previous research has questioned the extent to which conditioned reinforcers (i.e., tokens) can strengthen behavior (Shahan, 2013). Studies have shown that rate of token delivery does not differentially strengthen behavior (Shahan & Podlesnik, 2008). Thus, delivering tokens that signaled access to delayed reinforcement could have reduced the effects of quality of reinforcement for the current study.

Of these three potential explanations, I chose to further evaluate potency. Potency of reinforcement has been shown to affect rate of responding and choice responding, and is often correlated with the quality of reinforcement. Thus, in Experiment II, I focused on the potency of the reinforcer in addition to the participant's relative preference for specific reinforcers.

Reinforcer Potency

Preference assessments are commonly conducted prior to behavioral assessment and treatment (Call, Trosclair-Lasserre, Findley, Reavis, & Shillingsburg, 2012) because more preferred stimuli function as reinforcers more often than less preferred stimuli (Fisher et al., 1992; Roane et al., 1998; Roscoe et al., 1999). It is common for preference assessments to identify several preferred stimuli that appear to function equally as reinforcers (Francisco, Borrero, & Sy, 2008). Thus, the extent to which higher quality stimuli are important to include as reinforcers in behavioral treatment programs comes into question, especially if lesser preferred stimuli function as reinforcers (Francisco et al., 2008). High quality reinforcers, such as providing time with friends, playing basketball in the gym, or computer time, are sometimes difficult to access, and so educators often rely on smaller, less preferred reinforcers (e.g., pencils, stickers) to increase appropriate behavior. Although these reinforcers may maintain responding under low response requirements, the higher quality stimuli may be needed to reinforce responding as response requirements increase.

Evaluations of reinforcer potency identify the response conditions under which stimuli function as reinforcers (Roane, 2008). Stimuli identified as high preferred under low response requirements may not function as reinforcers under high response requirements. It therefore seems reasonable to hypothesize that stimuli that maintain responding under high response requirements (i.e., more potent stimuli) would have greater effects on strengthening task completion than would stimuli that reinforce responding at a lower response requirement (i.e., less potent stimuli). The purpose of Experiment II was to evaluate the persistence of task completion when it was reinforced with a relatively more or less potent reinforcer.

The demand for the more potent reinforcer became elastic at a relatively low response requirement for all three participants. Elasticity refers to the pattern of consumption for a reinforcer (Reed, Niileksela, & Kaplan, 2013). Demand for a reinforcer is inelastic if responding for that reinforcer remains consistent as the unit price to access that reinforcer increases (Francisco et al., 2009; Reed et al., 2013). Conversely, demand for a reinforcer is elastic when responding decreases or becomes variable as the unit price to access that reinforcer increases. Demand for a reinforcer that is more inelastic, meaning that the stimulus reinforces responding at a higher unit price than another stimulus, is described as being more potent (Francisco et al., 2009; Roane et al., 2001). The demand for the more potent reinforcer for Nick, Ricky, and Jalen became elastic following small increases to unit price. Thus, only mildly potent reinforcers were used in Experiment II. Nonetheless, results were consistent with my hypothesis for two of three participants. Ricky and Jalen clearly showed greater persistence of task completion under the stimulus condition associated with the delivery of the more potent reinforcer. Nick's results were inconsistent as very modest increases in persistence were associated with the less potent reinforcer. Although these data support the hypothesis that reinforcer potency differentially strengthens behavior, what is needed is a parametric analysis of reinforcer potency and persistence of task completion. For example, reinforcers that maintain responding at eight to 16 times the amount of work may strengthen task completion considerably more than the mildly potent reinforcers used in this study. Nevin

(1995) showed a direct relation between inelasticity of demand for a reinforcer and the persistence of behavior used to access that reinforcer. Higher rates of reinforcement produced consistent responding following increases to response requirement and also produced greater persistence when disrupted. Other conditions that change the inelasticity of demand for a reinforcer may produce similarly persistent responding and warrant further analysis.

The results of Mace and colleagues (1997) and this study suggest that the quality of reinforcement delivered for appropriate behavior differentially strengthens that behavior. These higher quality reinforcers, then, may reduce the overall time needed for maintenance, as defined by Nevin and Wacker (2013), to be achieved. For this reason, it remains important for applied researchers to continue to isolate variables associated with reinforcement, besides rate, that consistently increase strength, even if only modest strengthening occurs.

Quality has been shown to compete with rate of reinforcement (Neef et al., 1992; Neef et al., 1994). Under concurrent schedules arrangements, responding for a higher quality reinforcer available according to a lean schedule of reinforcement was greater than responding for a lower quality reinforcer available according to a dense schedule of reinforcement. Quality was also shown to compete well against immediacy of reinforcer delivery and effort to access reinforcement (Neef et al., 1994). Immediacy and effort were shown to compete against rate in some cases. Thus, preference for a dimension of reinforcement can be individualistic, and evaluations of these other dimensions may be important to study in relation to behavioral persistence in a treatment context.

Experimenter and Task Variables

A concerning outcome of DRA treatment is the time it takes to achieve the maintenance of appropriate behavior without the resurgence of problem behavior (Wacker et al., 2011). Five of six participants (Sarie is the exception) in the current studies showed similar problems with maintenance. Aida and Jalen showed rapid decreases in task completion and increases in problem behavior following only a brief exposure to extinction. However, task completion increased before decreasing to near zero levels again for Jalen. Ricky and Nick showed more gradual decreases in task completion and increases in problem behavior following extinction. Darren's task completion was initially variable during extinction but ended consistently high, and task completion was always high for Sarie. The variability in these data differ somewhat from what has been previously shown in the literature. Wacker et al. (2011) showed decreases in task completion and increases in problem behavior following only 5-min of extinction in some cases. Five out of the six participants enrolled in this study (Aida being the exception) continued to complete their tasks at similar levels to the positive reinforcement analysis when they transitioned into the disruptor analysis. There are two plausible explanations for these data. First, experimenter attention may have become a conditioned reinforcer, and attention maintained task completion during the disruptor analysis. Second, the participants may have learned to prefer completing the tasks. Interestingly, two of the participants (Nick and Jalen) actually chose to work over play during all choice arrangements of the concurrent operants assessment of work and play.

All six participants showed low levels of task completion at some point during the time-contingent reinforcement analysis. Task completion increased and was maintained at high levels during the positive reinforcement analysis. During the positive reinforcement analysis, the experimenter delivered tokens contingent on task completion and then played with the participant during the reinforcement intervals. It is possible that the results from the disruptor analysis were modest for all participants because the experimenter continued to deliver tokens contingent on task completion. The participants did not have an extended history with the experimenter prior to beginning the study. Repeated pairings of task completion and token delivery/time in reinforcement may have conditioned experimenter attention as a reinforcer (Singer-Dudek, Oblak, & Greer, 2011). Thus, the experimenter delivering tokens during the disruptor analysis may have maintained task completion and masked the effect of quality of reinforcement. In future studies, one experimenter should deliver tasks and tokens and a second experimenter should deliver the reinforcement to decrease the likelihood of experimenter attention becoming a conditioned reinforcer. Similarly, persistence might be more differentiated if tokens are not delivered during the disruptor analysis.

Experiments I and II used conditioned reinforcers (i.e., initially neutral stimuli that are conditioned to increase response rate because they are paired with a primary reinforcer; Catania, 1998) to signal the amount of reinforcement delivered at the end of the 5-min work period. The presentation of each token represented 1 min of time with the reinforcer programmed for that stimulus condition. As employed by the current studies, the conditioned reinforcers served as “sign posts” or a “means to an end” (Shahan, 2010; 2013). Thus, conditioned reinforcers may have increased task completion because they signaled the amount of reinforcement the participant would earn after the 5-min work period. The combined use of conditioned and tangible reinforcement leads to the question of which source of reinforcement strengthened task completion.

Previous research has questioned the extent to which conditioned reinforcers strengthen behavior (Shahan & Podlesnik, 2008). In one study, Shahan, Magee, and Dobberstein (2003) arranged a chained multiple schedules design in which conditioned reinforcement was delivered according to a random interval (RI) 15-s schedule of reinforcement. The conditioned reinforcers were associated with either an RI 30-s or an RI 120-s schedule of food reinforcement. Results showed that responding persisted longest in the component associated with the higher rate of food reinforcement. These data were evidence that the terminal reinforcer, not the conditioned reinforcers, strengthened behavior.

Shahan and Podlesnik (2005) evaluated the strengthening effect of conditioned reinforcers by arranging a higher and lower rate of conditioned reinforcer delivery while keeping rate of terminal reinforcement constant. They arranged a mult RI 15-s RI 60-s schedule of reinforcement to compare the effect of rate of conditioned reinforcer delivery on behavioral persistence. The rate of primary reinforcement delivery was the same for both components. Results showed that the rich schedule of conditioned reinforcement resulted in increased response rate but no differences in persistence during disruption (Shahan & Podlesnik, 2008).

The experimental arrangement for my study programmed for approximately equal rates of conditioned reinforcement delivery and amounts of tangible reinforcement delivery. The independent variable was preference for (Experiment I) or potency of (Experiment II) the tangible reinforcement delivered. The studies conducted by Shahan and colleagues showed that it was the reinforcement delivered following the conditioned reinforcement that strengthened behavior. Thus, the current data support these findings that quality of reinforcement differentially strengthened responding and not the colored tokens that were used as conditioned reinforcement.

Wacker et al. (2011) showed that participants continued to complete their demands even as other behaviors, like manding, decreased. Thus, task completion showed the quickest persistence effects, possibly because the MOs for escaping the task were abolished. Other studies have shown that instructional strategies, like repeated practice, can improve compliance (McComas, Wacker, & Cooper, 1996). The participants in the current study had repeated practice with the demands and received error correction to help them learn the material. It could be that the repeated practice and error correction procedures decreased the difficulty of the demands and the participants learned to prefer completing the work.

Applied Implications

Translations of behavioral persistence have extended knowledge related to the resurgence of problem behavior during treatment (Mace et al., 2010; Wacker et al., 2011; Wacker et al., 2013). Resurgence occurs when treatment initially shows positive effects but problem behavior returns when treatment is withdrawn. Previous studies have shown that the rate of reinforcement delivered for appropriate behavior can decrease the likelihood of resurgence when treatment is withdrawn (Wacker et al., 2011). The results of the current study suggested that programming reinforcement contingencies to deliver a more potent reinforcer might strengthen appropriate behavior and decrease the likelihood that resurgence will occur during challenges to treatment. A common challenge to treatment occurs when a substitute teacher variably reinforces appropriate behavior. Appropriate behavior regularly contacts extinction in this case. It would thus be important for educators to implement procedures, like delivering more potent reinforcers for appropriate behavior, which will increase the strength of appropriate behavior so it persists during this challenge. Two examples of this are Ricky and Jalen from Experiment 2. Task completion initially persisted during extinction for both stimulus conditions and decreased more quickly under the stimulus condition associated with the delivery of the less potent reinforcer. Problem behavior returned at higher levels under this stimulus condition too. Thus, the current study showed that delivering a more potent reinforcer might help program for the persistence of appropriate behavior and decrease the likelihood of resurgence during treatment challenges.

Limitations

The participants enrolled in this study were recruited based on parent report of problem behavior occurring during work tasks. Baseline levels of task completion were obtained during the time-contingent reinforcement analysis, but no demonstration of a functional relationship between problem behavior and escape from demands occurred. Thus, it is unclear whether problem behavior that occurred during the time-contingent reinforcement analysis was maintained by negative reinforcement. This may be important because different results may occur with different classes of reinforcement. For example, if problem behavior was maintained by attention, this would support the hypothesis that therapist became a conditioned reinforcer.

A limitation related to the behavior economic analysis was related to the decision rules for discontinuing a condition. Although the reversal showed that raisins were more potent than iPad for Nick, the collective findings across participants suggests that more sessions should have been conducted for Nick. Future research should continue to investigate ways to study reinforcer potency. One avenue of research could investigate discrete versus continuous choice situations. Participants were not allowed to change choices after they made their initial selection during the current study. Other research has shown that allowing participants to freely change choices can be an effective way to measure preference (Neef et al., 1992; Neef et al., 1994). This could possibly be another way to conduct the behavior economic analysis to more clearly study reinforcer potency.

The demand for the reinforcers used during this study was elastic following small increases to unit price. Thus, an evaluation of the effect of more potent reinforcers did not occur. Future researchers may consider including highly preferred stimuli that are available only during experimental sessions. The value of these stimuli may be higher, and thus more potent, because the participants do not have regular access to them outside of the experimental sessions. Evaluation of the effect of reinforcer potency on persistence can occur only by including these highly potent reinforcers.

Conclusion

In summary, Experiments I and II from the current study showed modest effects consistent with the hypothesis that quality of reinforcement differentially strengthens behavior. Four of the six participants (Darren and Nick being the exceptions) showed greater persistence of task completion under the multiple schedules component associated with the delivery of the higher quality reinforcer. However, these effects were smaller than originally anticipated. As applied researchers continue to translate behavioral momentum, it will likely be the case that other factors (e.g., stimulus control) and dimensions of reinforcement (e.g., preference) will each contribute modest individualistic effects. Thus, just as the biggest effects in rate of behavior occur with the contingent application of a reinforcer, the biggest or most consistent effects in persistence may be the rate of reinforcer delivery. All other factors and dimensions may certainly have individual effects, but perhaps the most robust effects will occur most often with rate of reinforcement.

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