ABSTRACT

DISHABITUATION OF OPERANT RESPONDING IN PRESCHOOL-AGED CHILDREN

Motivational variables are a key factor in determining if a stimulus will function as reinforcement for a behavior. In behavior analysis, motivational variables are conceptualized as motivating operations (Laraway, Snycerski, Michael, & Poling, 2003), the most basic of which are deprivation and satiation; however, basic research has suggested that habituation and sensitization may play a role in regulating the efficacy of reinforcement (Kenzer, Ghezzi, & Fuller, 2013; McSweeney & Murphy, 2009). The procedure used to test for habituation was the dishabituation procedure. Given the widespread use of direct reinforcement procedures in applications of Behavior Analysis to bring about socially significant behavior change, this procedure could be useful to practitioners. Specifically, it may give practitioners working with individuals, such as those with Autism Spectrum Disorders, who have a limited range of reinforcers, some options to prolong or recover the effectiveness of reinforcing stimuli or events. The current study examined the effects of a dishabituation procedure on a simple operant task performed by typically developing children, using antecedent and consequence stimulus changes that would be common in a range of clinical applications. Results indicated that 2 out of 3 participants reliably showed stimulus specificity and dishabituation patterns following the stimulus manipulations and habituation with no stimulus specificity or dishabituation during control conditions.

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DISHABITUATION OF OPERANT RESPONDING IN PRESCHOOL-AGED CHILDREN

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CHAPTER 1: INTRODUCTION

The principle of reinforcement is the foundation of operant conditioning and plays an important part in most clinical interventions. Thus, it is imperative that stimuli functioning as reinforcers remain effective to attain necessary outcomes. The concept of motivating operations (MOs), environmental variables that increase or decrease the momentary effectiveness of a reinforcer, aided in this regard by providing a clearer definition of motivating variables that must be present for reinforcement to occur (Laraway, Snycerski, Michael, & Poling, 2003; Michael, 1982, 1993). In addition, this conceptual framework made it easier for researchers and clinicians to not only identify motivating variables, but also to manipulate them in the laboratory or in the field, leading to more function-based treatments and assessments. Two of the most basic MOs are deprivation and satiation. In behavior analysis, satiation typically describes “the effect of establishing (or abolishing) operations that decrease the momentary effectiveness of stimuli to serve as reinforcers” (Murphy, McSweeney, Smith, & McComas, 2003). Therefore, if reinforced responding were to decrease within-session while everything else remained the same, it may be assumed that the stimulus has lost its effectiveness as a reinforcer, and satiation has occurred.

Murphy et al. (2003) have argued that the term satiation be replaced for two reasons: 1) the term’s definition within behavior analysis is inconsistent with the definition used in other sciences in which satiation refers to the termination of eating and drinking behaviors, and 2) that the term labels behavior, but does not explain how one would go about manipulating its effects. For instance, the authors give the example of Ayllon’s (1963) study in which a hoarder who collected towels was provided with upwards of 600 towels. The intervention was effective in reducing hoarding, presumably by decreasing the reinforcing effectiveness of the towels, but does not suggest how this could be changed; that is, would satiation occur faster or slower if the size, color, or weight of the towels were different? Instead, it is argued that sensitization, defined as an increase in responding to a repeatedly presented stimulus (Groves & Thompson, 1970), or habituation, defined as a decrease in responding to a repeatedly presented stimulus (Groves & Thompson, 1970; Thompson & Spencer, 1966), may be a more parsimonious account of within-session changes in responding (Murphy et al., 2003).

In the respondent literature, habituation occurs when the magnitude of a reflexive response, such as a startle response, decreases as a result of repeated presentations of the same stimulus. Empirical research conducted thus far on habituation in the operant conditioning paradigm is sparse, with only five studies conducted with non-human animals as subjects (Aoyama & McSweeney, 2001a, 2001b; McSweeney, Kowal, Murphy, & Wiediger, 2005; McSweeney & Roll, 1998; Murphy, McSweeney, Kowal, McDonald, & Wiediger, 2006) and two with human subjects (Ernst & Epstein, 2002; Kenzer, Ghezzi, & Fuller, 2013); however, these studies have provided substantial evidence that habituation, rather than satiation, may occur during operant arrangements. More specifically, these studies have demonstrated habituation by testing for dishabituation. In the respondent literature, dishabituation is the primary test for habituation and refers to the recovery of responding to a stimulus following the presentation of an extraneous stimulus (Thompson & Spencer, 1966). A typical dishabituation procedure includes repeatedly presenting a stimulus until responding habituates, followed by presenting an extraneous stimulus, and then returning to the original stimulus. If the response recovers to or above the previous, habituated level when the original stimulus is returned, dishabituation has occurred.

To date, the only study that has successfully demonstrated dishabituation of an operant using human subjects was a laboratory study involving college students (Kenzer et al., 2013). Kenzer et al.'s (2013) findings may be particularly useful for other populations such as children with Autism Spectrum Disorder (ASD) who receive Early Intensive Behavioral Intervention (EIBI) services. Although the results are currently mixed, previous research has shown that children with ASD may habituate to stimuli at different rates than their typically developing peers, with some studies reporting more rapid rates of habituation and some slower (Szabo, 2014). This may lead to problems in treatment due to reinforcers losing their effectiveness within a session. The concept of satiation, as it is currently defined in behavior analysis, suggests few options in this situation. If a child in a clinical setting satiates to the reinforcer being used, the only answer may be to wait for the effectiveness of the reinforcer to recover; however, if habituation is indeed the contributing factor that led to the decrease in responding, a dishabituation procedure may be effective in, at the very least, temporarily reinstating the value of the reinforcer.

CHAPTER 2: LITERATURE REVIEW

Reinforcement and Motivation

The principle of reinforcement is the most well-established and important component of operant conditioning. According to Michael (2004), “when a type of behavior (R) is followed by reinforcement (S^R) there will be an increased future frequency of that type of behavior” (p. 30); however, there are factors that must be considered with respect to whether or not a given stimulus or event will function as reinforcement, including the immediacy of the consequence, the antecedent stimuli present when the behavior occurs, and the level of motivation in relation to a specific consequence (Cooper, Heron, & Heward, 2007). The level of motivation is an important factor to consider because motivation is necessary for a stimulus to function as reinforcement.

Keller and Schoenfeld (1950) coined the term “establishing operation” to describe the relationship between motivating variables in the environment and their effect on the occurrence of behavior; however, the term was not widely used until Michael (1982, 1993) reintroduced the term, stating that establishing operations affect behavior in two ways: 1) by altering the value of a consequence and 2) by momentarily evoking all behaviors that have preceded that specific consequence. More recently, Laraway et al. (2003) suggested the term be replaced by “motivating operation” (MO), which would encompass both establishing operations (EO) and abolishing operations (AO). Laraway et al. (2003) defined an EO as “any event that increases the effectiveness of a given consequence,” and AO as “any event that decreases the effectiveness of a given consequence” (p. 409). As for how EOs and AOs affect behavior, Laraway et al. (2003) also suggested the use of “evocative effect” and “abative effect” to describe increases or decreases in responding due to MOs (p. 412).

The concept of MOs has had important implications for the principle of reinforcement. By manipulating EOs and AOs, the effectiveness of a stimulus as a reinforcer can be strengthened or weakened. Two common methods of manipulating MOs involve deprivation and satiation. When an organism is deprived of a stimulus or event, the value of that stimulus or event as a reinforcer increases, resulting in an increase in the probability of a behavior that has preceded that reinforcer in the past. Conversely, when an organism is sated on a reinforcer, the value of the reinforcer decreases, resulting in a decrease in the probability of a behavior that has preceded that reinforcer in the past. The effects of deprivation and satiation on behavior have been demonstrated numerous times across species and reinforcers (Gewirtz & Baer, 1958; Klatt, Sherman, & Sheldon, 2000; North & Iwata, 2005; Vollmer & Iwata, 1991; Zhou, Iwata, & Shore, 2002); however, there are problems of concern for behavior analysis regarding the use of terms like satiation to explain behavioral variation.

One problem with using the term satiation to explain variation in responding is that the behavior analytic definition of satiation is not consistent with the definition typically used in the satiety literature. In behavior analysis, satiation has been defined as “an establishing operation that…occurs as a function of prior exposure or access to that reinforcer” (Hagopian, Crockett, van Stone, DeLeon, & Bowman, 2000, pp. 433-434; Michael, 1982) and “is presented continuously or for extended periods within and across sessions” (p. 434). This implies that satiation can occur with a variety of reinforcer modalities as long as the reinforcer is presented for long periods of time; however, in satiety research, satiation describes biological changes, and is influenced by “factors that contribute to the termination of ingestive behaviors such as feeding and drinking" (McSweeney & Murphy, 2009, p. 190). This discrepancy has methodological implications for behavior analysis. Given the biological definition of satiety, satiation should only occur if edible stimuli are used for reinforcement. In addition, satiation should be more likely to occur within-session or across back-to-back sessions. If, for example, session-by-session data show a decrease in responding, but it is not specified when sessions took place (i.e. back-to-back or on separate days), it is, at best, unclear if the decrement is due to satiation or some other factor. Thus, for the remainder of this paper, the term "satiation" will refer to biological satiation as it is defined in the satiety literature, unless otherwise noted.

One way to investigate these factors is to collect more intimate data (Fahmie & Hanley, 2008). According to Fahmie and Hanley (2008), one of the advantages of within-session data collection is that it increases the observer's ability to view underlying behavioral processes that otherwise may be overlooked when data are collected and displayed by session, by phase, or by condition. A prime example of within-session data collection being used to uncover an underlying behavioral process is the line of research conducted by Francis McSweeney and colleagues regarding within-session variation in operant responding. McSweeney, Hatfield, and Allen (1990) found patterns of what appeared to be systematic, within-session decreases in rats' lever and key pressing that were uncommon in their line of research (McSweeney & Roll, 1993). The changes observed were large and orderly, being observed across "both responses, both reinforcers, all subjects, and all sessions" (McSweeney & Hinson, 1992, p. 21). A search of the literature yielded a large number of published studies, dating as far back as 1933, which all contained similar variations in within-session responding (McSweeney & Roll, 1993). According to McSweeney and Murphy (2009), several potential explanations for the changes in responding were proposed, all of which were tested and rejected, including:

> Recovery from handling (McSweeney & Johnson, 1994), anticipation of events that follow the session (e.g. feeding or handling, McSweeney, Weatherly, & Swindell, 1995), changes in a general motivational state (e.g. arousal, McSweeney, Swindell, & Weatherly, 1996a, 1996b), changes in interference from adjunctive behaviors (McSweeney et al, 1996a) or exploration (Roll & McSweeney, 1997), changes in factors produced by the act of responding (e.g. muscular warmup, fatigue; McSweeney, Weatherly, & Roll, 1995; McSweeney, Weatherly, Roll, & Swindell, 1995); Melville, Rybiski, & Kamrani, 1996; Weatherly, McSweeney, & Swindell, 1995), and changes in "attention" to the operant task defined in several ways (McSweeney, Roll, & Weatherly, 1994; McSweeney, Weatherly, & Swindell, 1996; Melville & Weatherly, 1996). (p. 190)

Because the studies conducted to test these potential explanations exclusively used edible reinforcers, another possible explanation was that a reduction in reinforcer effectiveness due to satiation was responsible for the decrements in responding (McSweeney & Murphy, 2009). To rule out this possibility, focus was shifted toward testing a number of different factors related to satiety.

Roll, McSweeney, Johnson, and Weatherly (1995) examined the potential roles of caloric density, deprivation, and stomach loading. If caloric density were a factor, responses reinforced with foods containing a higher number of calories would have been expected to begin to decrease earlier in the session than foods with lower amounts of calories, which also would have caused decreases in responding to be steeper than with foods containing a lower number of calories. If deprivation played a role, animals that were more deprived would be expected to become sated less quickly than animals that were less deprived. Thus, responding would be expected to begin to decrease earlier in the session for less deprived animals than for more deprived animals. If satiation were due to stomach loading, or simply the animal's stomach being physically filled with food, it would have been expected that the patterns of responding would begin to decrease earlier in the session for animals that received a larger amount of food per reinforcement than those that received less food per reinforcement. Results indicated that these factors did not change within-session responding that was followed by edible reinforcement, suggesting satiation was unlikely to be the sole cause of the behavioral variation observed. Similarly, Temple, Giacomelli, Roemmich, and Epstein (2008) demonstrated that the size of a reinforcer made little difference in response decrements, adding evidence that stomach loading was an unlikely contributor to within-session decrements in responding.

The final satiety factor investigated was the possibility that habituation to the sensory properties of the reinforcer may be responsible for decrements in their effectiveness. To test this possibility, McSweeney and Roll (1998) applied the primary test for habituation, a dishabituation procedure, in which a novel stimulus, or dishabituating event, is briefly presented following a marked decrease in responding, before returning to the original conditions. In particular, the process involved the experimenters altering either the schedule of reinforcement or the magnitude of reinforcement following a decrease in responding. When the original schedule or magnitude was returned, responding recovered, indicating that satiation or fatigue were unlikely contributors to the prior decrements, and that habituation was the most parsimonious explanation for the decrease in the effectiveness of the reinforcer. These and subsequent findings have led to a number of applied and theoretical implications, including the concept of habituation serving as an AO that plays a role in regulating the effectiveness of a stimulus as a reinforcer (McSweeney, 2004; Murphy et al., 2003).

Habituation

Habituation has been a topic of study since the late-nineteenth century (Thompson, 2009) and has been called "perhaps the most ubiquitous phenomenon in animal behavior" (Harris, 1943, p. 385). Traditionally studied in the respondent conditioning paradigm in regard to reflexive responding, habituation is defined as a decrease in responding due to repeated presentation of a stimulus (Hinde, 1970, as cited in Kenzer et al., 2013). A common procedure used to test habituation is to measure startle responses to sudden stimuli (Groves & Thompson, 1970). For example, an organism may display a startle response when presented with a loud tone; however, the startle response will systematically decrease if the organism is exposed to frequent, repeated presentations of the same tone.

Thompson and Spencer (1966) developed a list of nine characteristics of behavioral habituation, which has been recently updated by Rankin et al. (2009). Three important characteristics included spontaneous recovery, dishabituation, and stimulus generalization. Spontaneous recovery refers to a previously habituated response reappearing after the passage of time. For example, a startle response that has habituated in the presence of a loud tone will occur again when the tone is presented following a period of time in which the tone is absent. This initially led researchers to consider the possibility that the decrement in responding could be due to fatigue, because the passage of time could constitute a rest period for the organism (Schwartz & Robbins, 1978); however, this factor can be ruled out by demonstrating another characteristic of behavioral habituation: dishabituation.

Dishabituation is the primary test for habituation and refers to the recovery of the habituated response *after* a novel or extraneous stimulus is presented. For example, if the startle response to a loud tone habituates before being exposed to a novel tone, the habituated response will recover once the initial stimulus is returned. Dishabituation is the primary test for habituation, because if a response recovers after initially showing signs of habituation, it is unlikely the original decreasing pattern in responding was due to other factors such as fatigue or satiation (Kenzer et al., 2013; McSweeney, 2004; Thompson & Spencer, 1966). Another important characteristic of habituation is stimulus generalization. Stimulus generalization refers to a response that has previously habituated to one stimulus continuing to habituate in the presence of a physically similar stimulus. That is, if a novel stimulus is similar enough to the stimulus that was presented while the response habituated, the habituation effect will generalize to the novel stimulus (Rankin et al., 2009). Furthermore, the presentation of a novel stimulus that is physically *different* from the original stimulus may increase responding in the presence of that novel stimulus, demonstrating stimulus specificity. This is important to note, because stimulus specificity can be demonstrated without dishabituation (e.g., Ernst & Epstein, 2002), and because demonstrations of stimulus specificity are often mistaken for demonstrations of dishabituation (Kenzer et al. 2013; Rankin et al., 2009). For instance, in the previous example of a dishabituation procedure, if the novel stimulus presented following habituation of the startle response results in recovery of the response, stimulus specificity has been demonstrated; however, to demonstrate dishabituation of the response, responding must recover once the original stimulus is re-presented.

Shortly after Thompson and Spencer's (1966) publication, Groves and Thompson (1970) expanded on the characteristics of habituation and proposed the dual-process theory of habituation, which argued that another process, sensitization, occurs alongside habituation. The theory argued that repeated presentation of a stimulus not only led to habituation of a response, but also could simultaneously lead to increased responding that has an effect on habituation. That is, when a relatively weak stimulus is repeatedly presented, there will be less sensitization, and the response to that stimulus will habituate more quickly. In contrast, when a more intense stimulus is presented, sensitization is higher, so responding might stay higher, with habituation occurring less rapidly. Returning to the previous example of a rat's startle response to the presentation of a loud tone, the first few presentations of the tone will produce higher magnitudes of sensitization, resulting in higher response magnitude, which will decrease systematically depending on the intensity of the stimulus. When the novel tone is presented following the initial systematic decrease, sensitization will return, briefly, followed by yet another systematic decrease in responding as the novel stimulus continues to be presented. Similarly, when the original tone is represented, sensitization will again lead to increased responding, which will again systematically decrease as the tone continues to be presented. Thus, sensitization to stimuli explains not only the brief increase in responding that is sometimes seen during the initial trials of a habituation procedure, but it also accounts for the increases in responding seen during tests for stimulus specificity and dishabituation.

Habituation of Operant Responding

Until recently, habituation and sensitization had not been investigated in the operant conditioning paradigm. In fact, Harris (1943) went as far as stating, "There seems no doubt that a response which is reinforced in any of the common ways will not be markedly affected by habituation, although of course decrement may occur, as in satiation" (p. 413). Although research on the subject is limited, and the empirical studies that have been conducted have been limited to mostly "non-human animals (e.g. rats and pigeons), edible reinforcers (e.g., water, grain, ethanol), and dishabituation conditions involving changes in the schedule of reinforcement, reinforcer magnitude, and introduction of extraneous stimuli" (Kenzer et al., 2013, p. 63), these studies have quite consistently demonstrated a number of the behavioral characteristics of habituation, including spontaneous recovery, stimulus specificity, and most importantly, dishabituation, with the only difference being the dimension of measurement: rate of response instead of magnitude.

McSweeney and Roll (1998) were the first to provide empirical evidence that habituation may be responsible for within-session changes in operant responding by demonstrating dishabituation of key pecking in four pigeons, using grain as a reinforcer. All sessions lasted 60 min, and took place daily, five to six times per week. During baseline, pecking a white light produced 5 s access to grain on a fixed-interval (FI) 30 s schedule. Forty minutes into the session, a test phase was implemented for 2 min, during which a change in the schedule of reinforcement or the magnitude of the reinforcer was introduced. The change included randomly altering the schedule of reinforcement from FI 30 s to FI 5 s, from FI 30 s to extinction, from FI 30 s to providing "three reinforcers for the next three responses whenever a reinforcer was scheduled" (McSweeney & Roll, 1998, p. 431), or changing the magnitude of the reinforcer by allowing 20 s of access to the reinforcer. Following the test phase, the original schedule or reinforcer magnitude was re-introduced. Results indicated that average rates of responding increased above the average rates of responding during baseline for all changes in the reinforcer, except for the change from FI 30 s to extinction. These results provided strong evidence that habituation, rather than satiation, was responsible for the decrements in responding seen during baseline, because during these conditions, the rate of reinforcer delivery was higher than in baseline. In addition, McSweeney and Roll (1998) noted that the failure to produce dishabituated responding in the FI 30 s to extinction condition was not particularly surprising, since demonstrating dishabituation by removing a stimulus had proved difficult within the habituation literature.

The next study in this line of research also focused on the schedule of reinforcement as a dishabituating event. In their first experiment, Aoyama and McSweeney (2001a) demonstrated dishabituation of lever pressing in eight experimentally naïve male Wistar rats using 45 mg Noyes food pellets as reinforcers. All sessions were 45 min long. During baseline, lever pressing was reinforced on a fixed-ratio (FR) 4 schedule of reinforcement for the first 21 min of the session, followed by 3 min of one of four test conditions: 1) a no-lever condition, 2) an FR 6-2 condition, in which lever pressing was reinforced on an FR 6 schedule and reinforcement size increased to two food pellets, 3) an FR 8 condition, and 4) an FR 2/FR 6 condition, under which reinforcement for lever pressing alternated between an FR 2 and an FR 6 schedule of reinforcement. Following the test conditions, the baseline condition was reintroduced for the remaining 21 min of the session. Results indicated that average rates of responding increased above baseline levels following the test condition, regardless of which condition was presented. These results suggest that habituation contributes to within-session decrements in operant responding under high-rate schedules of reinforcement. In addition to demonstrating dishabituation, in their second experiment, Aoyama and McSweeney (2001a) compared the patterns of habituation under FR and variable ratio (VR) schedules. Results indicated that responding on FR schedules showed more rapid habituation than VR schedules.

McSweeney et al. (2005) demonstrated dishabituation of lever pressing in five rats by not only manipulating the schedule of reinforcement, but also by introducing an extraneous stimulus. All sessions lasted 60 min. During baseline, lever pressing was placed on a variable-interval (VI) 15 s schedule, followed by experimental conditions in which extinction, a continuous reinforcement (CRF) schedule, or a flashing light were presented 15, 30, or 45 min into the session, for 5 min. This was followed by a return to baseline conditions identical to the previous baseline. The experimental conditions presented were chosen randomly at the beginning of each session, so there was no chance of two conditions directly following each other. These conditions were conducted until each rat had been exposed to each variable at least 10 times. Results indicated that dishabituation of responding occurred for all subjects following all changes in stimuli.

In another study on the effects of extraneous stimuli as a dishabituating event, Aoyama and McSweeney (2001b) demonstrated dishabituation of wheel running in eight Sprague-Dawley rats using the wheel brake and the house lights of the operant chamber. All sessions were 30 min long. Baseline consisted of 20 min and 55 s of free running time and was followed by 5 s of one of two test conditions. The first test condition, the brake test, involved alternating between applying the wheel's brake for 1 s and then releasing it for 1 s until 5 s had elapsed. The second test condition, the light test, involved alternating between turning the operant chamber's house light off for 1 s and then on for 1 s until 5 s had elapsed. Following the test conditions, baseline was reintroduced, and free running was allowed. Results indicated that rates of responding increased to levels above baseline for all subjects following both test conditions.

Finally, in a study similar to Aoyama and McSweeney (2001b), Murphy et al. (2006) demonstrated dishabituation of lever pressing in five P rats. The reinforcer used was a solution containing 10% ethanol, and the subjects were provided 5 s access upon completion of the response requirement. All sessions lasted 50 min and were conducted on a daily basis, five to six times per week. During all sessions, with the exception of the flash test described below, the house lights and left stimulus light stayed lit during all conditions, but were turned off for 5 s during reinforcement. Baseline consisted of 24 min and 55 s of responding on a VI 15 s schedule, followed by one of two test conditions. The first test condition, the tone test, involved alternating between turning a 60 decibel tone on for 1 s and then off for 1 s, until 5 s had elapsed. The second dishabituating event, the flash test, involved alternating between turning the house lights and the operant chamber's left stimulus light off for 1 s and then on for 1 s, until 5 s had elapsed. For the remaining 25 min of the session, conditions were returned to the VI 15 s schedule present in baseline. Results indicated that rates of responding increased to levels above baseline for all subjects following the presentation of the tone. In contrast with previous research (Aoyama & McSweeney, 2001b), levels did not increase after flashing of the lights; however, the authors point out that due to the success of the tone as a dishabituating event, the failure to demonstrate dishabituation using flashing lights may be due to other factors, such as the rats used in the current study having poor vision compared to other strains of laboratory rats. In addition, the authors cite that during the current study, the flash condition differed from Aoyama and McSweeney's (2001b) flash condition, in that the house light "was constantly illuminated, except during the dishabituation manipulation" (p. 479), going on to explain that in the current study, "the house and stimulus lights were extinguished and illuminated approximately 60 times before the dishabituation manipulation occurred within the session" (p. 479). Therefore, habituation of responding due to the house and stimulus lights may have already occurred (Murphy et al., 2006, p. 479).

Dishabituation of Operant Responding with Human Participants

Although dishabituation has been demonstrated a number of times in the operant conditioning paradigm using non-human animals as subjects (Aoyama & McSweeney, 2001a, 2001b; McSweeney et al., 2005; McSweeney & Roll, 1998; Murphy et al., 2006), to date, only two studies have attempted to demonstrate dishabituation of operant responding with human participants.

Ernst and Epstein (2002) tested for stimulus specificity and dishabituation of a computer-based operant in 35 male undergraduate students. Participants were randomly placed in one of two groups, a group that received the same edible reinforcer continuously and another group who received a variety of foods on a VR 32 schedule. The first phase consisted of eight, 5 min trials, which served as the habituation phase. This was followed by a 5 min novel stimulus phase, during which the previous reinforcers were replaced with chocolate bars. The final phase was a return to the original reinforcers. Results failed to demonstrate dishabituation of responding. The authors suggest that one possible reason for these results may have been satiation. Two factors that may have contributed to satiation include the stimuli used as reinforcers during the original stimulus condition and the length of the conditions themselves. The edible stimuli present in the original stimulus condition were foods high in calories, such as sandwiches and chips. In addition, participants were eating these foods for 40 min before the novel stimulus was presented. Another possibility, cited by the authors, may have been the use of chocolate as the novel stimulus. The authors suggested there may have been discriminatory properties to chocolate that were not foreseen, since, in a natural environment, sweet foods like chocolate are often presented after a meal (Ernst & Epstein, 2002). Thus, the chocolate may have served as a discriminative stimulus (S^d) to stop eating.

Kenzer et al. (2013) tested for habituation of mouse-clicking responses on a computer screen. Forty-nine undergraduate students participated in the study. Forty-six of the participants were exposed to a test condition, while the remaining three were exposed to a control condition. The test condition consisted of a three-phase reversal design: 1) an original stimulus condition, 2) a novel stimulus condition, and 3) a return to the original stimulus condition. The control condition consisted of only the original stimulus condition. The original stimulus phase served to demonstrate habituation by continuously presenting reinforcement contingent on a mouse-clicking response. During the first 2 min of the original stimulus phase, average rates of responding were calculated for each participant. The response was determined to have habituated when rates of responding decreased to, or below, 33% of the average rate of responding during the first 2 min. If the average rate of the first 2 min equaled eight responses per minute or less, the average rate of the second and third minutes were used. Once habituation had occurred, the novel stimulus condition was implemented for 2 min. The novel stimulus phase served as a test for stimulus specificity. It consisted of "changes in the 1) reinforcer value, 2) reinforcer type, 3) reinforcer amount, 4) schedule of reinforcement, or 5) antecedent stimuli" (Kenzer et al., 2013, p. 65). The value of various edibles (e.g., M&Ms, pretzels, crackers), social statements (e.g., "Good job," "Awesome," "Excellent work"), and picture sets (e.g., male or female celebrities, nature scenes) was assessed using a preference questionnaire prior to the sessions. If the rate of responding during the first minute of the novel stimulus phase was equal to, or more than, the rate of responding during the final 2 min of the original stimulus condition, stimulus specificity had been demonstrated. The return to the original stimulus phase tested for dishabituation of responding to the previous stimulus. If rate of responding returned to, or increased above, the rate of responding in the last 2 min of the original stimulus condition, dishabituation had been demonstrated.

Results indicated that 37 out of 46 participants exposed to both the novel stimulus and the return to the original stimulus conditions showed recovery in responding, demonstrating both stimulus specificity and dishabituation. In addition, the participants exposed to the control condition all showed decrements in responding within session that persisted, suggesting the novel stimulus condition was responsible for changes in responding. During change-in-reinforcer value sessions (i.e., moderately preferred edible or social statement to highly preferred edible or social statement), 7 out of 8 participants showed response patterns that indicated dishabituation. During change-in-reinforcer type sessions (i.e., moderately preferred edible to social statement, social statement to edible, edible to picture set, or social statement to picture set), 11 out of 13 participants showed response patterns that indicated dishabituation. During schedule change sessions (i.e., FR4 to FR8 or FR4 to FR2), 3 out of 4 participants' response patterns indicated dishabituation under the FR4 to FR8 condition, and 1 out of 3 participants exposed to the FR4 to FR2 condition showed response patterns that indicated dishabituation. During change-in-reinforcer amount sessions (i.e. medium to large edible or medium to small edible), 7 out of 8 participants' response patterns indicated dishabituation. During antecedent change sessions (i.e., green to red square, red to green square, location of the square), 6 out of 7 participants exposed to the color change showed response patterns that indicated dishabituation. Three participants were exposed to the change in the square's location, and all showed patterns that indicated dishabituation. Overall, results indicate that changes in reinforcer value, changes in reinforcer type, changes in reinforcer amount, changes in the reinforcement schedule, and changes in antecedent stimuli can produce dishabituation of operant responding in humans; however, failures to produce dishabituation also occurred for each type of change that was implemented.

An important implication that can be derived from the results of Kenzer et al.'s (2013) study is that habituation, rather than satiation, indeed appears to be the AO that resulted in the response decrements observed in the original stimulus condition. The response recovery observed in the change in reinforcer value and change in reinforcer amount sessions provides further evidence that decrements in operant responding to edible items may not always be due to satiation. In the change in reinforcer value sessions, if the decrease in responding observed during the original stimulus condition were due solely to satiation, the decreases would be expected to continue, despite the change in value. This was not the case. As was previously demonstrated in studies with non-human animals (Aoyama & McSweeney, 2001a; McSweeney & Roll, 1998), the same is true for the change in reinforcer amount sessions. If the decreases in responding observed during the original stimulus condition were due solely to satiation, the decreases would be expected to continue, regardless of the size of the reinforcer. In addition, considering the biological definition of satiation as a "decrease in consumption of an edible stimulus as that stimulus is repeatedly consumed, due to physiological factors" (Kenzer et al., 2013, p. 74), satiation cannot account for the decreases and recovery of responding that were observed during sessions in which social statements or picture sets served as reinforcers. Instead, it appears the more parsimonious explanation may be that the repeated presentation of the stimuli resulted in an AO that decreased the stimuli's ability to sustain responding.

Kenzer et al. (2013) contributed immensely to the literature on habituation in the operant conditioning paradigm by being the first to demonstrate dishabituation of operant responding with humans; however, perhaps the largest contribution of Kenzer et al.'s (2013) study is that it serves as a strong foundation for future research. As previously noted, failures to produce dishabituation were observed in all of the types of changes implemented. Future research focusing on these failures may lead to more clearly defined parameters of stimulus changes that are necessary for dishabituation to occur. One direction for research suggested by the authors was to vary the antecedent stimulus changes across more modalities and to use stimuli with different properties. For example, more robust change was observed for conditions in which there was a change of location of antecedent stimuli than when changes to the color of the antecedent stimulus occurred, suggesting that some stimulus modalities may be more sensitive to dishabituation than others. The authors also suggested that future studies use a variety of different response topographies.

In addition to those noted by the authors, future research might also extend Kenzer et al.'s (2013) methodology to clinically relevant populations. Although further research is required, Murphy et al. (2003) have previously outlined some potential clinical applications that take advantage of habituation and sensitization, one of which involves using specific techniques to control the effectiveness of reinforcers that maintain desired behaviors. According to Murphy et al. (2003), interventions that require dense schedules of reinforcement may benefit from techniques to slow habituation and increase sensitization. For example, if an intervention is using an edible reinforcer on a dense schedule, using a variety of reinforcers, on a variable, rather than a fixed schedule, and introducing a change in some extraneous variable in the environment could increase the effectiveness of the reinforcer. Techniques could also be implemented to decrease the effectiveness of a reinforcer that maintains a problematic behavior by increasing the speed of habituation. For example, one common intervention for reducing problem behavior is noncontingent reinforcement (NCR). Noncontingent reinforcement procedures often involve the repeated presentation of stimuli identified as a reinforcer on a time-based schedule. The reduction in behavior that is observed when using NCR procedures may be due to a habituation effect brought on by the repeated exposure to stimuli that are known to maintain the behavior. In a clinical setting, if the goal is to decrease problem behavior quickly, dense fixed-time schedules should increase habituation and may be advantageous to the practitioner. In this case, variation in reinforcers and the introduction of extraneous variables should be limited for the procedure to be most effective. Future research that investigates these assertions could have a large impact, particularly in the treatment of individuals with ASD.

Treatments that take habituation and sensitization into account could be useful to those who provide EIBI services. In a clinical setting, behavioral programming can last for long periods during which habituation may occur. If responding decreases within a session, and satiation is suspected, there are not many options available, particularly if the child lacks a range of preferred items that function as reinforcers. Previous research has suggested that rotating reinforcers can be important as a preventative measure (DeLeon, Anders, Rodriguez-Catter, & Neidert, 2000), but if the child only responds to a small number of stimuli, or only one specific stimulus, it is important these stimuli continue to be effective to ensure optimal learning.

In these types of situations, other options are needed, and the use of a dishabituation procedure similar to the one developed by Kenzer et al. (2013) may be an easy, efficient way to increase the reinforcing value of a stimulus. Furthermore, Kenzer et al. (2013) demonstrated that manipulations of antecedent stimuli could be sufficient in producing response recovery; however, aside from the results of that study, little is known about what types of manipulations will be sufficient in producing dishabituation. Moreover, Kenzer et al. (2013) also demonstrated that a brief change in the type of edible reinforcement was sufficient in producing response recovery. This provided more evidence toward habituation and sensitization playing larger roles as MOs than satiation and deprivation in regard to within-session decrements in reinforced responding.

Therefore, the purpose of the current study was three-fold. The primary purpose was to extend Kenzer et al.'s (2013) procedure to a different human population by recruiting typically developing children as participants. Second, we sought to add to the growing literature suggesting that habituation and sensitization act as AOs and EOs, respectively, and that neither biological satiation nor the broader term often used in behavior analysis are always sufficient in accurately explaining decrements in reinforced responding. And finally, a third purpose was to determine if changing antecedent variables that may be practical in a clinical setting, namely the stimuli used in a task or the agent facilitating the task, would be sufficient in producing dishabituation when the original stimuli were returned, providing some potential options for practitioners in Applied Behavior Analysis when they encounter a reinforcer that has lost its effectiveness within a session.

CHAPTER 3: METHODS

Participants, Setting, and Materials

Three typically developing females, ages 4 and 5 years old, were recruited through the Psychology Department at California State University, Fresno.

All assessment sessions were held in a room containing two tables; a large rectangle-shaped table measuring approximately 5 ft x 2.5 ft against one wall, and on the wall across from it, a child-sized table approximately 5 ft x 2.5 ft. Experimental sessions were conducted in a small observation room fitted with a one-way mirror on three of the walls. The room contained a square-shaped child-sized table, approximately 2 ft x 2 ft, two child-sized chairs, one adult-sized chair, a small cabinet to hold a laptop, and various materials related to the task. The data collector and a research assistant were present in the room with the participant at all times.

Materials used in the experiment included four to five, white 5 gal buckets, various stimuli for a sorting task (i.e., foam triangles, cube-shaped wooden blocks, and plastic poker chips), two small paper bowls, one for placing task stimuli and the other for placing edible reinforcers, a digital timer, and a MotivAider. Edible items (e.g., snack foods) or non-edible items (e.g., toys) were also present, depending on the condition being conducted. Research assistants were recruited from Fresno State Psychology classes and remained blind to the purpose of the study. Data were collected by the experimenter using paper data sheets and a MacBook Pro computer running Microsoft Office 2016. A GoPro Hero 3+ video camera was also used to record each session for further data collection purposes.

Experimental Sequence and Research Design

Each participant was exposed to two preference assessments prior to four experimental conditions. One preference assessment assessed preference for edible items and the second assessed preference for non-edible items. The experimental design was a reversal design used to measure dishabituation based on whether or not the response recovers following a brief change of the operant arrangement.

Dependent Variable and Interobserver Agreement

The dependent variable was the rate of responding per minute. The response measured was taking the task stimulus for that condition from the bowl on the left side of the participant, and, using either hand, releasing the stimulus into the hole in the lid of the designated bucket, one at a time. If at any time a participant had more than one stimulus from the bowl in their hands for more than 3 s before placing both stimuli into the bucket, only one response was counted. This definition was modified during Participant 1's sessions as the hole in the bucket was too small for the stimulus to fit through without affecting response rate, which also resulted in some responses missing the bucket. These responses were counted as correct responses for this participant as long as they were oriented in the direction of the bucket and landed within 2 ft of the bucket. To resolve this issue, the remainder of Participant 1's sessions were conducted with no lid on the bucket. The hole in the lid was widened for subsequent participants and only responses that were released into the bucket were counted as correct responses. In addition, any stimuli released onto the lid or left on the table were immediately removed by the research assistant and used to replenish the bowl until the response requirement was met.

A primary data collector was placed inside the room and collected frequency data for each response that occurred on a minute-by-minute basis. To account for consumption of the reinforcer, the timer was stopped upon delivery of the reinforcer and started again once the reinforcer had been consumed.

Interobserver agreement (IOA) was conducted for 50% of sessions for each participant using video recordings. An independent data collector viewed videos of the sessions and collected frequency data on a minute-by-minute basis. Interval by interval exact count agreement between the primary data collector and the reliability data collector was calculated by counting the total number of agreements in each minute, dividing them by the total agreements and disagreements in each minute, and multiplying by 100 to obtain a percentage of agreements for each minute in a session. Those percentages were then averaged by adding the percentage of agreement for each minute and dividing by the total number of minutes in the session. Mean IOA was 97.64% (range = 95.68% to 100%) for Participant 1, 92.02% (Range = 88.39% to 95.65%) for Participant 2, and 85.09% (range = 84.03% to 86.15%) for Participant 3. The mean IOA score across participants was 91.58% (range = 84.03% to 100%).

Preference Assessments

The participants were exposed to two preference assessments in order to determine highly preferred edible and non-edible items to serve as reinforcement in the experimental conditions. Prior to the Reinforcer Change condition, a multiple stimulus without replacement (MSWO) preference assessment was conducted using an array of five edible items (DeLeon & Iwata, 1996). The scoring method used was assigning points based on the order in which the item was chosen (Ciccone, Graff, & Ahearn, 2005). To determine which items would be used in the condition, the participants were given a choice between the two highest preferred items. If the assessment did not produce two highly preferred edibles, the item with the second highest score was used in the Original Stimulus Phase for the participant's Reinforcer Change condition.

For Participant 1, the items in the array included popcorn, pretzel sticks (broken in half), Goldfish, Twizzler Bites, and Oreo Minis. Her most preferred items were Oreo Minis and pretzel sticks. At the start of the session, she was presented with a choice of these two most highly preferred items and she selected Oreo Minis; however, after responding 51 times during the session, receiving 12 Oreo Minis, the session had to be terminated due to the participant requesting to use the restroom. To ensure that her exposure to the Oreo Minis did not affect the session when it was conducted again, the item was replaced with Starburst Minis and a new MSWO preference assessment was conducted. The second assessment indicated Starburst Minis and popcorn as the highest preferred items and were used in the condition (see Table 1). For Participant 2's and Participant 3's edible preference assessments, items in the array included M&Ms (all of which were blue to ensure changes in reinforcer color could not sensitize the response), Twizzler Bites (cut in half), pretzel sticks (broken in half), Goldfish, and popcorn. Participant 2's assessment indicated Twizzler Bites and M&Ms as highly preferred. Participant 3's assessment indicated M&Ms as highly preferred. Popcorn was the item with the next highest score and was used first in her Reinforcer Change condition.

Prior to the first condition requiring a non-edible reinforcer, a multiple stimulus without replacement (MSWO) preference assessment was conducted using an array of 7-10 items brought by the participants or provided by the experimenter (DeLeon & Iwata, 1996). The scoring method was the same utilized

Table 1

Reinforcers Utilized in Each Condition for Each Participant

Condition	Participant 1	Participant 2	Participant 3
Reinforcer Change	**Starburst Mini/Popcorn	**Twizzler Bite/M&M	**Popcorn/M&M
Research Assistant Change	Rabbit, hill, 2 carrots	Dinosaur	Slinky
Task Stimulus Change	2 orange dinosaurs	Rubber Fish	Purple Ball
Control (No Change)	iPad (Control 1)	Pink Snake	Rubber Fish
*Control 2	Coloring page, pink marker	N/A	N/A
*Control 3	Dinosaur	N/A	N/A

Note: *Two additional Control (No Change) conditions were conducted for Participant 1 (see Results and Discussion sections).
**Edible reinforcers used in the Original Stimulus Phase of the Reinforcer Change condition are listed first.

for the edible preference assessment (Ciccone et al., 2005). To determine which items would be used in the conditions, the participants were given a choice between the three highest preferred items. If the assessment did not produce three highly preferred edibles, the item with the third highest score was used. Following use of one reinforcer in a condition, it was removed from the next choice until only one remained.

The array in Participant 1's assessment included an iPad, toy train, stuffed unicorn, toy bus, Captain America action figure, coloring materials, and a maraca. The highest preferred items were the iPad, train, and unicorn. The iPad was used during the participant's Control condition that day; however, her mother did not bring the train and unicorn to subsequent sessions, so a second MSWO preference assessment was conducted, this time containing two orange toy dinosaurs, the toy bus, Captain America action figure, coloring materials, the maraca, a toy fish, and a Minion doll. The toy dinosaurs were chosen first, then coloring, and then the maraca; however, during a brief rapport building session prior to that day's condition, the participant accessed a game (Jumping Jack) from one of the additional rooms in the office and refused to enter the experiment without it. The experimenter allowed pieces from the game to be used in the next condition. The remaining conditions utilized items identified in the second preference assessment (see Table 1).

Participant 2's non-edible preference assessment array included five items provided by the experimenter (Batman action figure, slinky, rubber fish, minion, dinosaur) and five items brought by the participant (stuffed cat, pink snake, flashlight, doll, yo-yo). The highest preferred items identified by the assessment were the dinosaur and rubber fish. The item that received the next highest score was the pink snake.

Participant 3's non-edible preference assessment array included a slinky, truck, rubber fish, squishy ball, Batman action figure, stuffed Minion, and dinosaur. The rubber fish, purple ball, and Batman were ranked highest in the initial preference assessment; however, during the next session, the participant told the experimenter that she would not play with the Batman toy and wanted the slinky (the next highest ranked item, by one point) instead, so it was used in the condition.

Experimental Procedures

Each participant was exposed to four experimental conditions. For all participants, except Participant 1, conditions were assigned a random order prior to the beginning of sessions and were held on separate days, one to two times per week. Each of the experimental conditions included 1) an original stimulus phase, 2) a novel stimulus phase, and 3) a return to the original stimulus phase.

Following the preference assessments, the research assistant and experimenter engaged in a brief, 5 min rapport building session with the participant. The participant was then brought into the experimental room. In the center of the room, there was a child-sized table with two bowls on the left (for task stimuli to be placed) and right (for edible reinforcers to be placed) sides, near the participant. To the participant's right, there were two 5 gal buckets. To the left of the participant, positioned closer to the research assistant across the table, were three 5 gal buckets containing task stimuli. These buckets contained 1,488 pieces of 6 mm wide red foam that were cut into triangles with sides measuring approximately 3 in x 2 in x 2 in, 400 brown wooden cubes/blocks with 1 in sides, and 100 blue plastic poker chips, which measured approximately 1.5 mm thick with a 1 in diameter. The data collector sat in a chair behind the participant, in the corner of the room, to operate the timer and collect data. Prior to the start of the session, the research assistant presented an instruction to the participant regarding the response. The instruction varied slightly across participants and conditions, but always contained information regarding the required response and the reinforcement that would be provided contingent on the response. Variations included stating that the participant could go as fast or slow as they wanted and start or stop when they wanted.

Original Stimulus Phase

Once the instruction was given, the data collector started the timer and the research assistant began placing one task stimulus at a time into the bowl on the left side of the participant and replenishing following each response. Reinforcement was delivered on a fixed-ratio 4 (FR 4) schedule for all participants and remained constant throughout all conditions. For conditions in which non-edible items were used as reinforcers, the reinforcement interval consisted of 10 s access to the item or 3 s of non-engagement, whichever came first. For conditions in which edible items were used as reinforcers, the reinforcement interval consisted of the time it took to consume the reinforcer or 10 s of consumption, whichever came first, with the exception of Participant 1's Reinforcer Change condition, during which the participant was given approximately however long it took to consume the reinforcer, regardless of whether or not 10 s had elapsed. Following consumption of the reinforcer, the research assistant would provide a transition prompt, "time's up," while removing the reinforcer (when applicable), and replenishing the bowl with a task stimulus. This prompt was also provided in the Reinforcer Change condition, with the exception of Participant 1's session.

The original stimulus phase continued until habituation occurred or the participant reached minute 30 of the session. Habituation was defined as two consecutive minutes in which responding decreased to, or below, 33% of the average rate of responding across the first 2 min of the session (Kenzer et al., 2013). Each original stimulus phase contained two constant stimuli in place and one that underwent change during the Novel Stimulus Phase, with the exception of the Control condition. The research assistants present, the task stimuli, and the reinforcer delivered were dependent on the condition being conducted (see Table 2).

Table 2

Constant and Changing Stimuli for the Original Stimulus and Novel Stimulus Phases

Condition	Original Stimulus Phase	Novel Stimulus Phase
Research Assistant Change	**Research Assistant 1** Task Stimuli 3 (foam triangles) Reinforcer 3 (Non-edible)	**Research Assistant 2** Task Stimuli 3 (foam triangles) Reinforcer 3 (Non-edible)
Task Stimulus Change	Research Assistant 3 **Task Stimuli 1 (wooden cubes)** Reinforcer 3	Research Assistant 3 **Task Stimuli 2 (poker chips)** Reinforcer 3
Reinforcer Change	Research Assistant 3 Task Stimuli 3 **Reinforcer 1 (HP Edible)**	Research Assistant 3 Task Stimulus 3 **Reinforcer 2 (HP Edible)**
Control	Research Assistant 3 Task Stimuli 3 Reinforcer 3	**No Change**

Note: Changing stimuli for each condition are bolded.

<u>Novel Stimulus Phase</u>

Once the habituation criterion was met, the Novel Stimulus Phase began. The phase lasted 2 min (Kenzer et al., 2013) and consisted of a change in antecedent stimuli (i.e., a change in research assistants or a change in the stimuli used for the task) or the reinforcer (i.e., highly preferred edible item to highly preferred edible item). All other stimuli remained constant, including the task and the schedule of reinforcement (see Table 2). Stimulus specificity was defined as an average rate of responding across the Novel Stimulus Phase that is equal to, or above, the average rate of responding across the final 2 min of the Original Stimulus Phase.

Research assistant change. During this novel stimulus condition, the timer was stopped, the research assistant facilitating the task (RA-1) left the room, and a new research assistant (RA-2) entered and took the place of the other. For Participant 1's session, the research assistant that entered repeated the instruction at the beginning of the phase for this condition. For all others, the research assistant would enter silently, sit down, and provide the task stimulus.

Task stimulus change. During this novel stimulus condition, replenishment of the task stimulus (Task Stimulus 1, wooden cubes) from the original stimulus phase was discontinued by the research assistant and replaced with a different task stimulus (Task Stimulus 2, poker chips). For Participant 1's sessions, the timer was stopped, and the research assistant delivered a modified version of the instruction at the beginning of the phase. For the remaining participants, the stimulus change was not signaled.

Reinforcer change. During this novel stimulus condition, a highly preferred edible reinforcer (Reinforcer 1) from the original stimulus phase was discontinued by the research assistant and replaced with a different highly preferred edible reinforcer (Reinforcer 2) contingent on completion of the schedule requirement. For Participant 1 and Participant 2's sessions, a modified version of the instruction was represented prior to starting the phase. Participant 3's session contained an un-signaled change in the reinforcer.

Control (no change). During this condition, no changes to the antecedent conditions or to the reinforcer occurred when the habituation criterion was met.

Instead, after reaching criterion, the session continued for an additional 4 min with all stimuli remaining constant (see Table 2).

Return to Original Stimulus Phase

The return to the original stimulus phase was identical to the original stimulus phase but lasted only 2 min. For Participant 1's sessions and Participant 2's Reinforcer Change condition, the original instruction was given prior to beginning the phase. For Participant 2's remaining sessions and for all of Participant 3's sessions, all stimulus changes were un-signaled. Dishabituation of a response was defined as an average rate of responding across the Return to Original Stimulus Phase that is equal to, or above, the average rate of responding across the final 2 min of the Original Stimulus Phase (Kenzer et al., 2013).

Procedural Integrity

Prior to the experiment, undergraduate research assistants were recruited through the Psychology Department. All research assistants remained blind to the purpose of the study throughout the experiment, and were provided with written and verbal instructions, modeling, rehearsal, and feedback concerning how to perform their specific duties with respect to the overall procedures and each condition, including presenting discriminative stimuli and reinforcers at the correct times, providing the correct reinforcers during all portions of a session, and providing the reinforcer within 3 s of the target response. All research assistants were required to attain 100% correct responding on all experimental procedures in post-feedback probes.

Procedural integrity data were collected on 50% of each participant's sessions by an independent observer using video recordings. Data were collected on whether or not 1) reinforcers were delivered within 3 s of completion of the response requirement, 2) task stimuli were replenished within 2 s of the completion of a response for each response interval, 3) the "time's up" prompt was delivered only once following each reinforcement interval, and 4) whether or not any extraneous stimulation was presented by the data collector or research assistants during any response interval, reinforcement interval, or phase changes (see Appendix). Procedural integrity data were calculated as percent correct by dividing the number of correct implementations by the number of correct and incorrect implementations and multiplying by 100. The mean procedural integrity score across participants was 95.09% (range = 86.01% to 99.18%).

CHAPTER 4: RESULTS

For each participant's sessions, within-session rates of responding were examined for patterns that suggest dishabituation of the response had occurred. Patterns observed fell into the following categories: 1) habituation with stimulus specificity and dishabituation or 2) habituation without stimulus specificity or dishabituation. Conditions were assigned in random order for all participants, with the exception of Participant 1, who was exposed to two additional Control conditions after all conditions had been conducted once; however, for ease of analysis, data are displayed in a fixed order.

Figure 1 displays data for Participant 1's Reinforcer Change, Research Assistant Change, and Task Stimulus Change conditions. The top panel of Figure 1 depicts Participant 1's responding during the Reinforcer Change condition. During the Original Stimulus phase, one Starburst Mini was delivered on an FR 4 schedule of reinforcement. The reinforcer provided during the Novel Stimulus phase was popcorn. The habituation criterion for the session was five responses per minute (rpm). The average rate of responding during the first 2 min was 14.5 rpm. Responding remained stable until minute 7, during which responding gradually decreased and the habituation criterion was met. When the reinforcer change was implemented, responding increased drastically, to 18 and 19 rpm. When the original reinforcer was returned, responding reached 11 rpm before rapidly decreasing to 0 rpm for the final minute of the session. These patterns indicate habituation, stimulus specificity, and dishabituation of responding occurred.

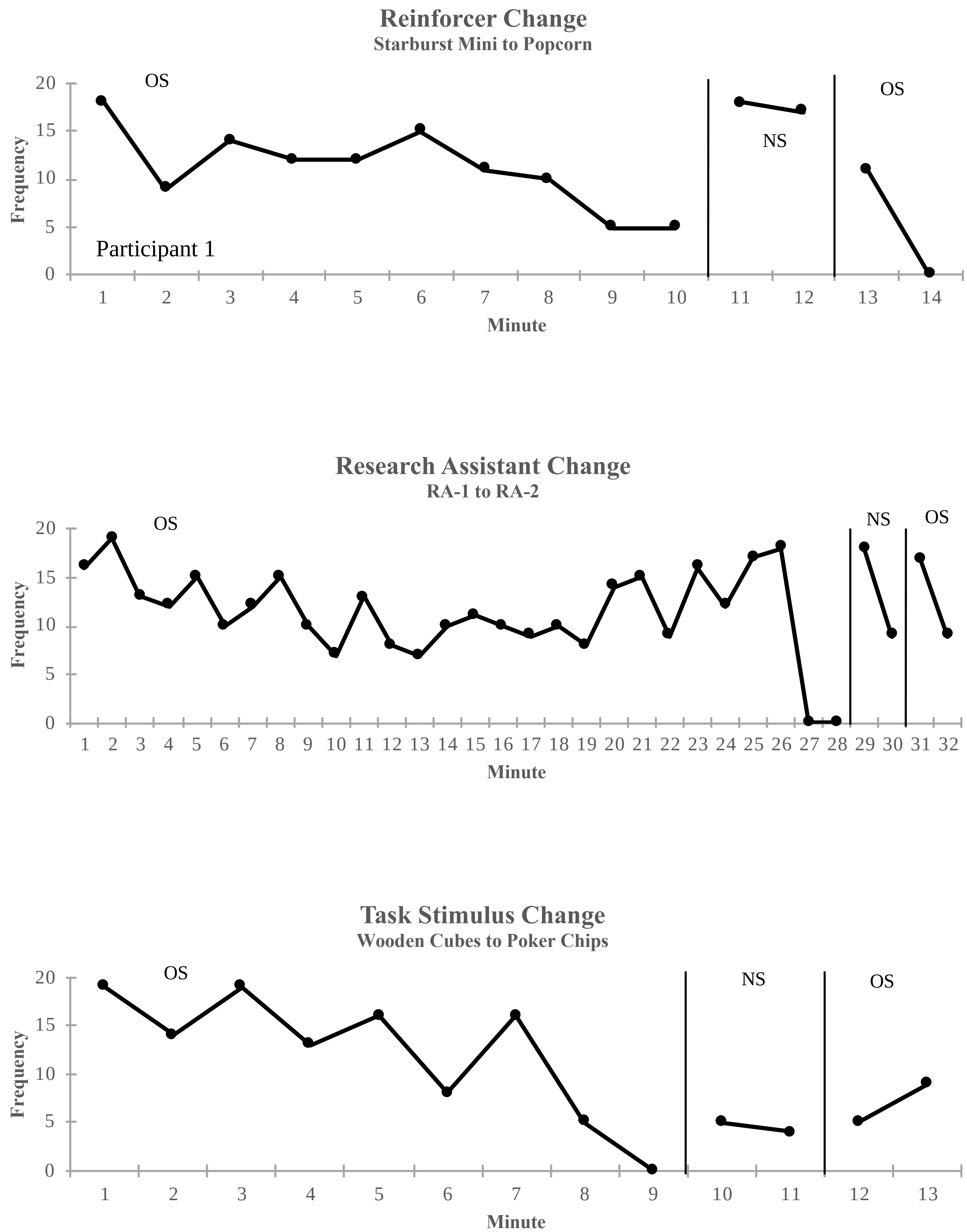
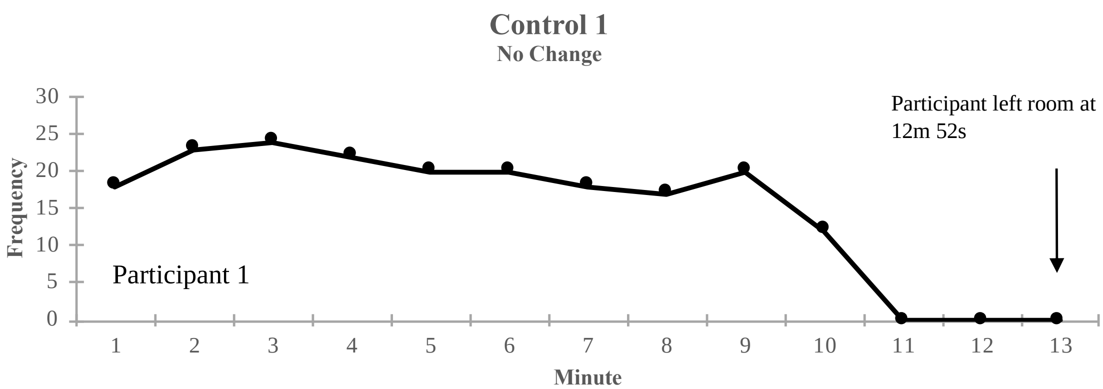


Figure 1. Rate of responding during the Reinforcer Change (Top), Research Assistant Change (Middle), and Task Stimulus Change (Bottom) conditions for Participant 1.

The middle panel of Figure 1 depicts Participant 1's responding during the Research Assistant Change condition. The reinforcer provided was assorted pieces of a game called Jumping Jack. Included were a toy rabbit, a hill the rabbit fits inside, and two toy carrots. The habituation criterion for the session was 6 rpm. Responding decreased gradually but remained highly variable throughout. Following an initial decrease toward the middle of the session, responding began to increase before decreasing significantly from 18 rpm to 0 rpm for the remaining 2 min of the Original Stimulus phase. Following the change in research assistants, responding significantly increased to 18 and 9 rpm, and when the original research assistant was returned, responding recovered again to 17 and 9 rpm. These patterns indicate habituation, stimulus specificity, and dishabituation of responding occurred.

The bottom panel of Figure 1 shows Participant 1's responding during the Task Stimulus Change condition. The reinforcers provided were two toy dinosaurs. The habituation criterion for the session was 6 rpm. Responding decreased gradually across the session until reaching criterion in minutes 8 and 9, at 5 and 0 rpm, respectively. Following the change from blocks to poker chips, responding recovered to 5 and 4 rpm. When the original task stimuli were returned, recovery was again observed, at 5 and 9 rpm. These data indicate that habituation, stimulus specificity, and dishabituation of responding occurred, although the patterns observed during the test for stimulus specificity are much less pronounced than with previous stimulus changes.

Figure 2 displays data for two Control conditions that were conducted for Participant 1. The top panel of Figure 2 depicts Participant 1's rate of responding during the first Control condition (Control 1) conducted. The non-edible reinforcer provided was an iPad. The habituation criterion for the session was 7 rpm. Participant 1's responding remained relatively stable until minute 10, during which responding decreased to 15 rpm, and finally, 0 rpm in minute 11. Responding remained at 0 rpm until the session was terminated due to the participant walking out of the room before the session was finished. Although these data appeared to indicate habituation had occurred and that responding did not recover, results may be viewed as inconclusive due to the session being terminated 3 min early.



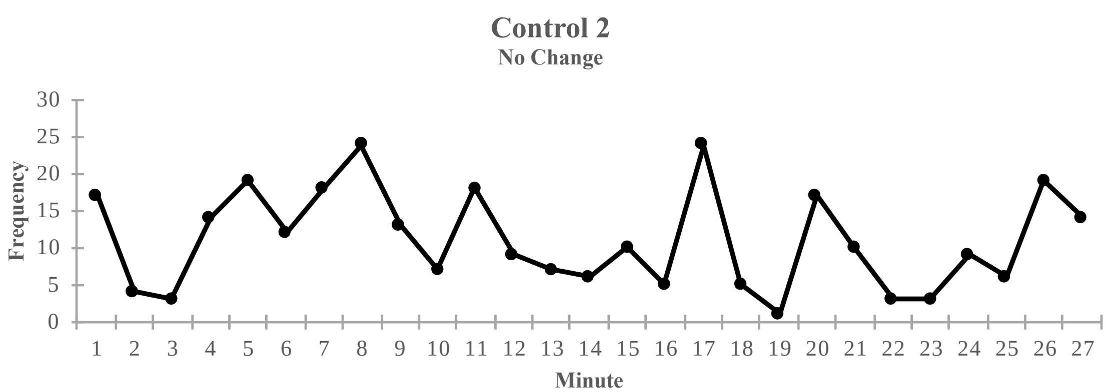


Figure 2. Rate of responding during Control 1 (Top) and Control 2 (Bottom) conditions for Participant 1.

The bottom panel of Figure 2 shows Participant 1's responding during the second Control condition (Control 2) that was conducted due to Control 1 being terminated prematurely. The reinforcer provided was a coloring page with a single pink marker. The habituation criterion was 4 rpm. Responding was highly variable for the entire session. The average rate of responding during the first 2 min was 10.5 rpm and responding prior to reaching the habituation criterion ranged between 1 rpm and 24 rpm. After meeting the habituation criterion, responding showed a dramatic recovery, reaching 19 and 14 rpm in the final 2 min (see Chapter 5: Discussion).

Figure 3 depicts Participant 1's rate of responding during a third Control condition (Control 3) that was conducted three months after Control 2 (Figure 2, bottom panel. This Control condition was conducted to compare to Control 2, in which stimulus specificity and dishabituation patterns were observed, despite no novel stimuli being presented. The reinforcer delivered was a toy dinosaur. The habituation criterion was 3 rpm. Responding decreased drastically during minute 4 to 0 rpm. It should be noted that during this time, the participant, with a task stimulus in hand, had dropped to her knees on the floor to where neither the research assistant nor the data collector could see whether or not she had released the task stimulus in her hand; therefore, the research assistant did not replenish the bowl until signaled by the data collector at the beginning of minute 5 that the stimulus had been released. To account for this minute during which the bowl was not replenished, an extra minute was added to the end of the session and habituation was determined to have occurred during minutes 5 and 6. Responding remained at or below the habituation criterion for the remainder of the session, indicating habituation without stimulus specificity or dishabituation.

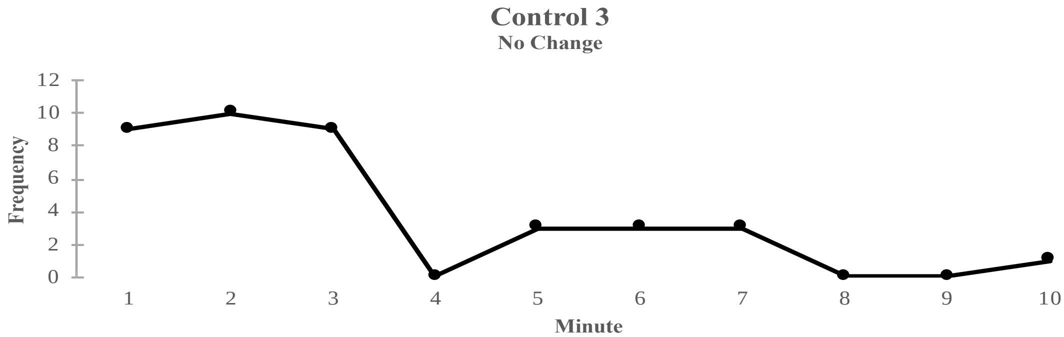


Figure 3. Rate of responding during the Control 3 condition for Participant 1.

Figure 4 displays data for Participant 2's Reinforcer Change, Research Assistant Change, and Task Stimulus Change conditions. The top panel depicts Participant 2's rate of responding during the Reinforcer Change condition. The reinforcers delivered during the Original Stimulus phase were Twizzler Bites, and the reinforcers provided during the Novel Stimulus phase were blue M&Ms. The habituation criterion was 6 rpm. Responding decreased gradually across the session until criterion was met during minutes 21 and 22, at 5 and 4 rpm, respectively. Following the change in reinforcers, responding recovered to 13 responses for both minutes of the phase. When the original reinforcer was returned, recovery of responding compared to previously habituated levels was observed, indicating both stimulus specificity and dishabituation of the response.

The middle panel of Figure 4 depicts Participant 2's responding during the Research Assistant Change condition. The reinforcer delivered was a toy dinosaur. The habituation criterion was 5 rpm. The average rate of responding during the first 2 min was 13.5 rpm and rapidly decreased to 5 rpm and 2 rpm. Following the change in research assistants, responding recovered to 8 rpm and 7 rpm. When the original research assistant returned, responding returned to 8 rpm and then to 0 rpm for the final minute. These data indicate that habituation, stimulus specificity, and dishabituation were observed.

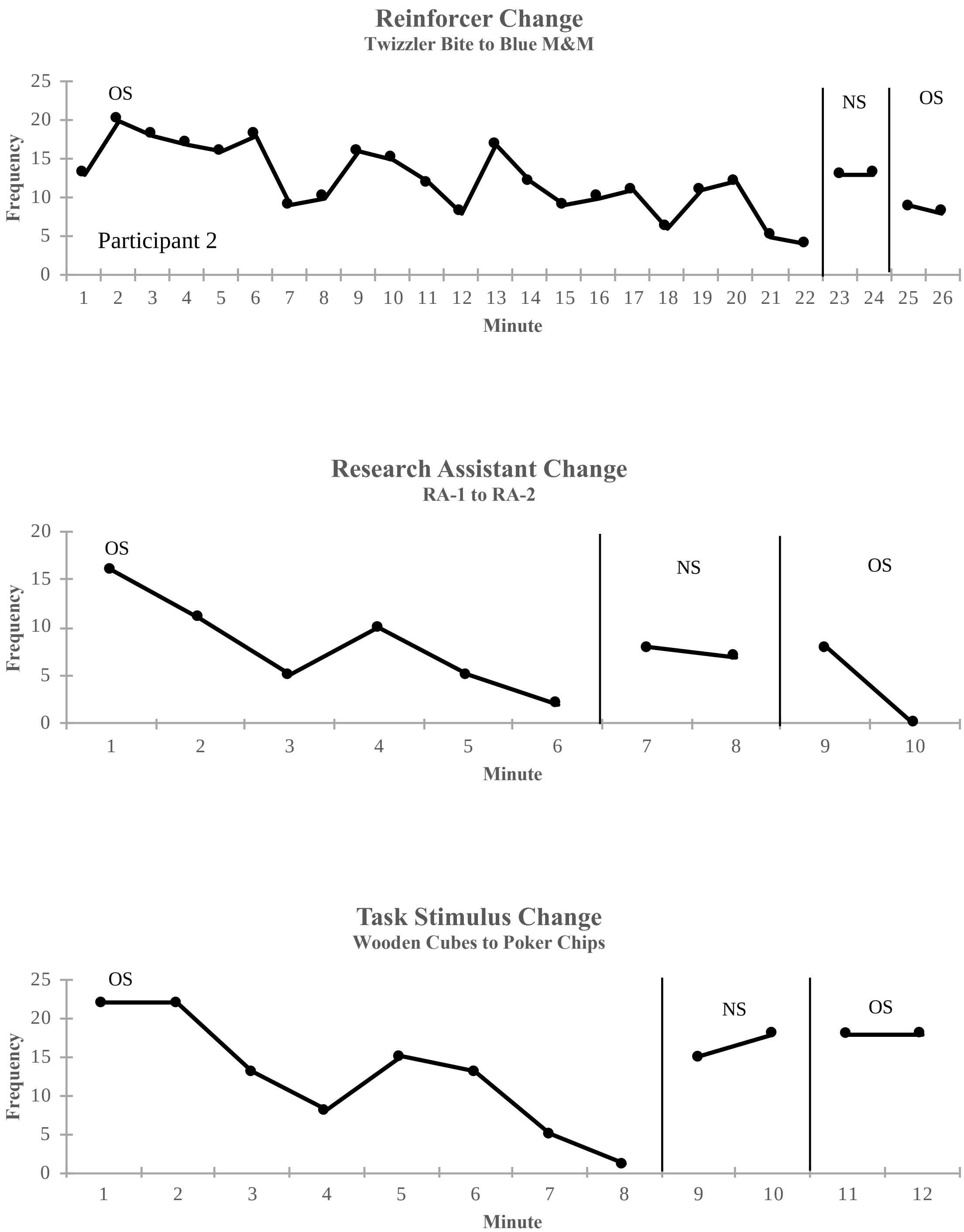


Figure 4. Rate of responding during Reinforcer Change (Top), Research Assistant Change (Middle), and Task Stimulus Change (Bottom) conditions for Participant 2.

The bottom panel of Figure 4 depicts Participant 2's rate of responding during the Task Stimulus Change condition. The reinforcer delivered was a rubber fish toy. The habituation criterion was 7 rpm. Responding decreased rapidly during this session, with a slight recovery during minutes 5 and 6, before another rapid decrease. Criterion was reached during minutes 7 and 8. Following the change in task stimuli, there was a robust recovery of responding to 15 and 18 rpm. When the task stimuli were returned in the final phase, responding remained at 18 rpm for both minutes. This pattern demonstrates both stimulus specificity and dishabituation of the response.

Figure 5 depicts Participant 2's rate of responding during the Control condition. The reinforcer delivered was a purple snake toy. The habituation criterion was 4 rpm. Responding in this condition decreased dramatically after the first 2 min. The decrease was followed by a brief recovery in minute 6; however, responding quickly decreased to 0 rpm and maintained for the remainder of the session; therefore, no stimulus specificity or dishabituation was observed.

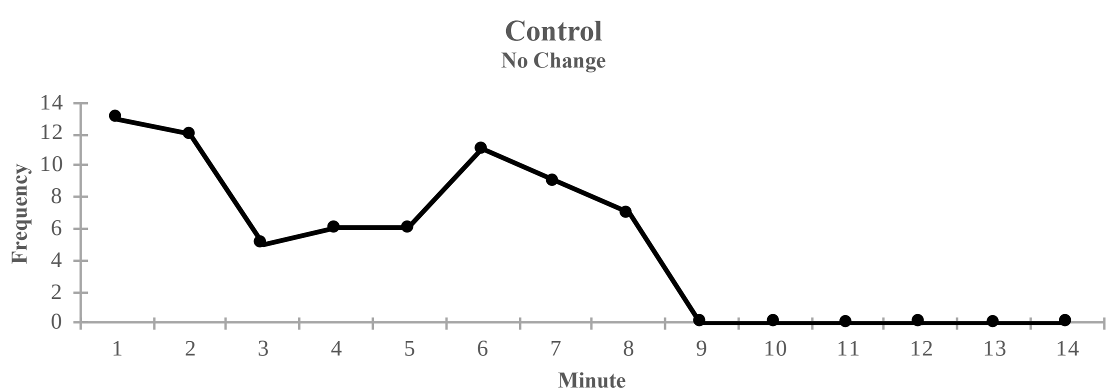


Figure 5. Rate of responding during the Control condition for Participant 2.

Figure 6 displays data for Participant 3's Reinforcer Change, Research Assistant Change, and Task Stimulus Change conditions. The top panel of Figure

6 depicts Participant 3's rate of responding during the Reinforcer Change condition. The edible reinforcers delivered during the Original Stimulus Phase were popcorn. The edible reinforcers delivered during the Novel Stimulus Phase were blue M&Ms. The habituation criterion was 3 rpm. Responding decreased gradually across the session until criterion was reached in minutes 22 and 23. Following the change of the reinforcer, responding increased to 9rpm in minute 24 and 4 rpm in minute 25, and in the final 2 min increased to 5 rpm in minute 26 before decreasing to 0 rpm for the final minute. These data indicate that habituation, stimulus specificity, and dishabituation were observed.

The middle panel of Figure 6 depicts Participant 3's rate of responding during the Research Assistant Change condition. The non-edible reinforcer delivered was a plastic slinky. The average rate of responding during the first 2 min was 11.5 rpm. The habituation criterion was set at 4 rpm. Rate of responding decreased gradually across the session and criterion was reached when rate of responding fell to 2 rpm and 0 rpm in minutes 15 and 16, respectively. Following the change in research assistants, responding increased to 10 rpm in minute 17 and 6 rpm in minute 18. During the final 2 min, responding occurred at 8 rpm and 3 rpm. These data indicate that habituation, stimulus specificity, and dishabituation were demonstrated.

The bottom panel of Figure 6 depicts Participant 3's rate of responding during the Task Stimulus Change condition. The non-edible reinforcer delivered was a purple squishy ball. The average rate of responding during the first 2 min was 20.5 rpm. The habituation criterion was 7 rpm. Rate of responding remained high through minute 3 before decreasing drastically and reaching criterion in minute 5 and minute 6. In the Novel Stimulus Phase, responding increased to 5 rpm during minute 7, then decreased to 0 rpm in minute 8. When the original task

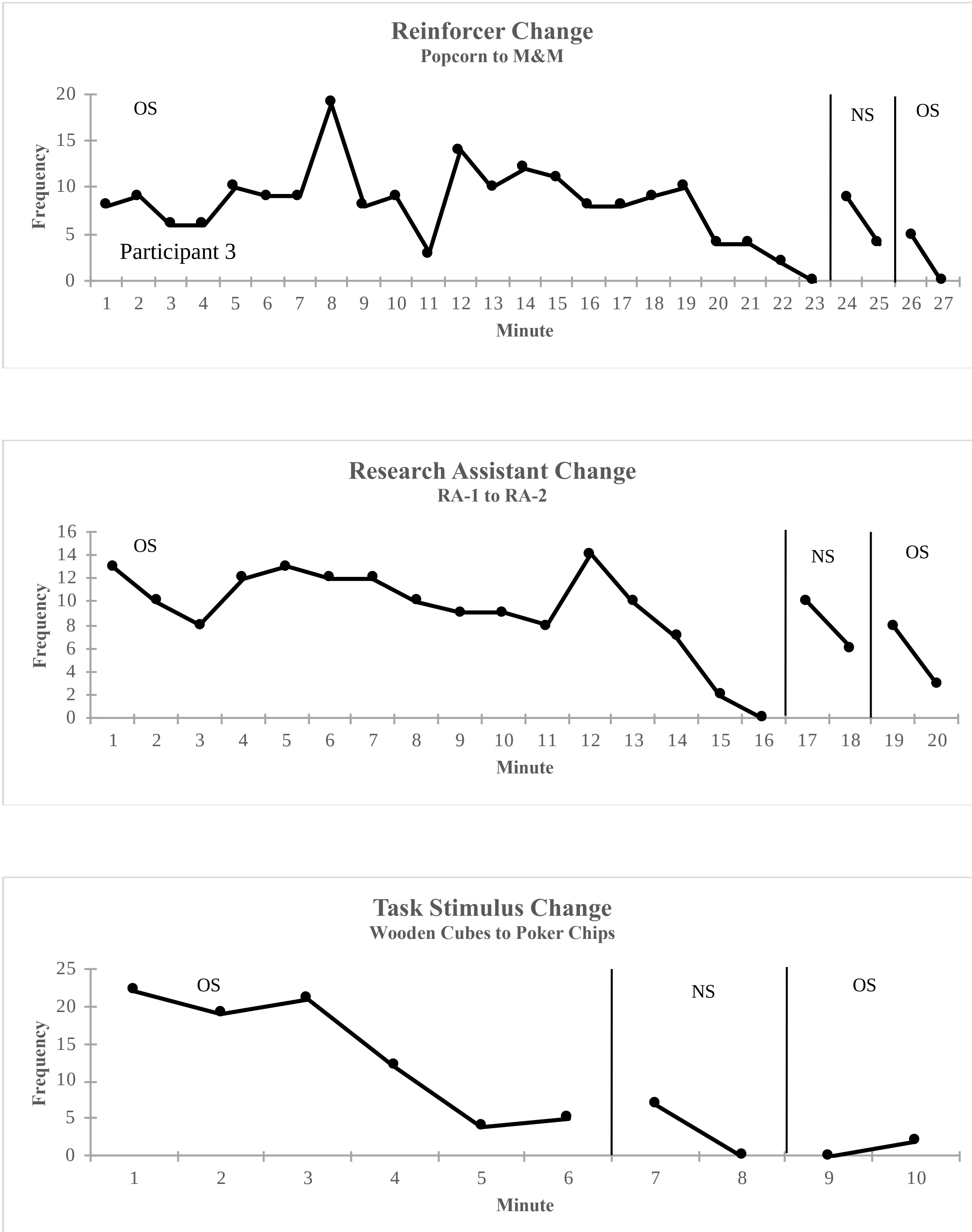


Figure 6. Rate of responding during Reinforcer Change (Top), Research Assistant Change (Middle), and Task Stimulus Change (Bottom) conditions for Participant 3.

stimuli were returned for the final 2 min, responding remained at 0 rpm during minute 9 before increasing to 2 rpm in the final minute. These patterns are indicative of habituation without stimulus specificity or dishabituation.

Figure 7 depicts Participant 3's rate of responding during the Control condition. The non-edible reinforcer delivered was a rubber fish toy. The average rate of responding during the first 2 min was 22 rpm. The habituation criterion was 7 rpm. Rate of responding decreased from 9 in minute 9, to 1 rpm and 3rpm in minutes 10 and 11, respectively. After reaching criterion, responding remained below 3 rpm for the remainder of the session, indicating habituation occurred without stimulus specificity or dishabituation.

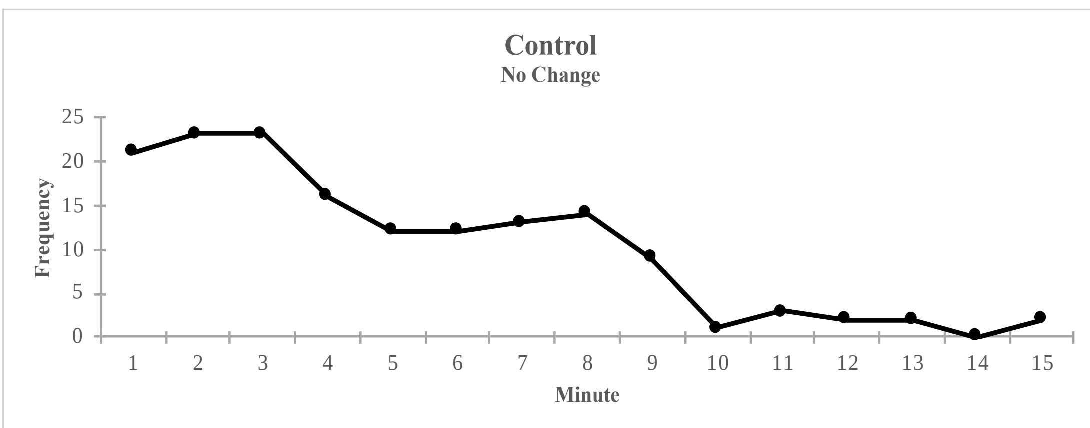


Figure 7. Rate of responding during the Control condition for Participant 3.

CHAPTER 5: DISCUSSION

The primary purpose of the current study was to extend the procedure used in Kenzer et al.'s (2013) study to a new human population using a novel operant and examine whether or not similar results would be obtained. In total, across participants, 8 of the 9 conditions conducted which included a Novel Stimulus phase resulted in both stimulus specificity and dishabituation of the operant response. Two of the three completed Control conditions conducted resulted in habituation with no stimulus specificity or dishabituation patterns. Therefore, the results suggest that the stimulus changes in the Novel Stimulus phases of the experimental conditions were responsible for the patterns observed for those participants, Participant 2 and Participant 3, but that they may not have been responsible for the patterns observed in Participant 1's experimental conditions; however, there were also environmental variables surrounding Participant 1's Control 2 condition that may have affected the data.

Overall, the frequency and duration of Participant 1's exposure to the experiment during each visit may have affected results for Control 2. For Participant 1, attempts were made to complete multiple sessions in one visit. Participant 1's first visit included six attempts, in which sessions were not completed due to the participant either leaving the room or stating she needed to use the restroom. Control 1 was the second attempt at completing a session, and occurred approximately 30 min into the first visit, following one previous failed attempt. The Reinforcer Change condition was the final attempt and only other session completed this day. The second visit was also a longer visit, and occurred one month later, due to holidays falling immediately after the first visit. During this visit, the Research Assistant Change condition was conducted successfully, and an attempt at the Task Stimulus Change condition was made but was terminated due to rate of responding not reaching the habituation criterion by minute 30. A third visit was made one week later, during which the Task Stimulus Change condition was completed, followed by Control 2. These visits, containing multiple attempts, may have affected responding by making aspects of the experiment aversive by the time the second Control condition was conducted. There were indicators of this possibility throughout the third visit.

For example, upon arrival, it was reported by the participant's mother that she had difficulty in getting the participant to go with her to come to the session that morning. Prior to sessions, the participant engaged in protesting behavior when presented with stimuli for the preference assessment and also when initially told by her mother that it was time to enter the room for the experiment. After completing the Task Stimulus Change condition, the participant was given a 20 min break, during which she played with her sister. Following the break, the participant initially hid under a table from her mother and refused to choose a reinforcer for the condition. Upon further inspection of the video recordings of the condition, there were also indicators present during the session. Throughout Control 2, including near the time she reached the habituation criterion, the participant engaged in various escape responses, such as telling the research assistant she needed to use the restroom or that she was finished. Later in the session, she also began forcefully scribbling or pounding the marker down on the coloring page that was being used in the condition. This was often accompanied by verbal responses like, "I'm done" or "Are we done yet?" In order to minimize any extraneous variables that might interfere with habituation of the response or serve as a confound in the experimental conditions, after providing the initial instruction regarding the task, the research assistant was instructed not to speak or provide any attention during the procedure, aside from presenting the “time’s up” prompt, once, following each reinforcement interval. Given the indications prior to the session that an EO for escape was in place, it is possible that the responding that resembles stimulus specificity and dishabituation in Participant 1’s Control 2 condition was actually part of the behavioral variability produced by extinction the participant was experiencing after repeated escape responses that occurred without acknowledgement. For subsequent participants, visits were made one to two times per week and contained only one session per visit, which overall, appeared to decrease the chance of the conditions becoming aversive to the participants.

In order to clarify the results of Participant 1’s conflicting Control conditions, a fourth visit was scheduled 3 months after the initial visits and Control 3 was conducted. No escape responses were observed before or during this session, indicating that the time between sessions may have reduced the aversiveness of the experimental conditions and the EO for escape responses. Moreover, rates of responding more closely resembled rates of responding both during Control 1 and those observed in the Control conditions of the other two participants. Overall, results of Participant 1’s Control 2 condition may call into question the nature of the effects observed in other conditions. The results of Control 3 make this possibility less likely; however, it is still a possibility, nevertheless.

Another factor that may have affected Participant 1’s sessions, particularly the Research Assistant Change condition, was the use of reinforcers that were made up of more than one piece. In the Research Assistant Change condition, for example, multiple pieces from a game were used (a toy rabbit, a hill it fit into, and two carrots), and may have served to sensitize the response at various times throughout the session. Upon review of the video recordings, there were times where the participant would refuse some pieces of the reinforcer when it was presented, but engage with one specific piece (e.g., the carrots), or accept all of the pieces, but engage more with a single piece than another. This variation may have been responsible for the slow progression of the session. This also may have been the case with Control 2, given that the reinforcer used was coloring. Attempts were made to decrease the amount of stimuli used, by only providing one marker, but the inclusion of two different items may have been sufficient in having an unintended sensitization effect, leading to slower habituation. Interestingly, the Task Stimulus Condition also contained a reinforcer that was multiple pieces; however, the reinforcer used was two identical items, which may have led to faster habituation than conditions with more than one different item. For the remaining participants, non-edible reinforcers were restricted to single items.

For Participant 2, one observable trend was that, aside from the Reinforcer Change Condition, sessions were consistently shorter than the other participants. One reason for this is that following the Reinforcer Change Condition, which was also the first condition conducted with this participant, the research assistant was instructed to begin removing any stimuli that was released anywhere other than inside the bucket. This change was made because in a terminated attempt to complete the Task Stimulus Change condition, the participant began to stack the blocks used in the condition on top of the bucket. Following implementation of this procedure, sessions became much shorter and also began to follow a similar pattern, in which responding gradually decreased, saw a slight increase, and then met the habituation criterion shortly after. For example, in minutes 6, 5, and 4 of the Task Stimulus Change, Control, and Research Assistant Change conditions, respectively, responding increases before a steady decrease to criterion. Interestingly, this may show that extinction was occurring simultaneously. During these sessions, presumably as the reinforcer began to lose value, the participant would show increased engagement with the task stimuli. Engagement with the task stimuli in ways other than intended was extinguished by the research assistant removing the excess stimuli, resulting in a brief burst of responding, and followed by more pronounced habituation of the response.

For Participant 3, it typically took longer to meet the habituation criterion than with Participant 2, with the exception of the Task Stimulus Change condition, which was also the only experimental condition in the study that did not show patterns indicating both stimulus specificity and dishabituation. There are a few issues that may have influenced the results of this condition. During all previous conditions, Participant 3 engaged in various other responses, such as asking questions to the research assistant and telling the data collector that the bucket was full when it was not. In addition, in the session immediately prior, the participant began to engage in whining behaviors approximately 30 s before the session was completed. Whining behaviors were also observed in the Task Stimulus Change condition, and coupled with the lack of attention from the research assistant and experimenter, may have served as a potential variable that led to the weak stimulus specificity and lack of dishabituation in that condition. For example, prior to the stimulus change, the participant had begun to whine prior to getting up and beginning to tap on the shoulder of the data collector. She eventually sat down again in time for the first stimulus change; however, during minute 8, after numerous requests, the participant stood up, and with her back turned to the research assistant facilitating the task, began tapping on the experimenter’s hand and shoulder repeatedly, saying, “Excuse me.” The participant remained with her back turned into minute 9 when she turned away for long enough that the experimenter could provide the signal for the task stimuli to change back to the wooden blocks. The participant turned and saw the stimulus change occur; however, she returned to the experimenter for the entire first minute of the phase before returning to her chair and responding twice, just before the session ended. In this case, it is possible that the alternative behavior the participant was engaging in, again possibly induced by contacting extinction from the research assistant, resulted in the stimulus change functioning differently than it did for the other participants who experienced the change while sitting at the table. Additionally, the increase in intensity of responses made toward the research assistant and data collector may have been a sign that, despite limiting visits to once or twice a week and decreasing the time spent during those visits, exposure to the experimental conditions may have become aversive for this participant and that escape had become a more valuable reinforcer than the reinforcer in the condition. Repeated exposure to the procedures may have also resulted in attention from the adults in the room becoming a more salient reinforcer than the designated reinforcer provided for completion of the task.

Another purpose of the current study was to add to the literature suggesting that habituation and sensitization function as MOs that regulate reinforcer effectiveness, and that satiation may not always be an adequate explanation for within-session decreases in responding. The Reinforcer Change condition was designed to demonstrate that biological satiation was an unlikely explanation for within-session decreases in responding by utilizing a stimulus change from one highly preferred edible reinforcer to another highly preferred edible reinforcer. Given that responding reliably recovered to levels above the previously habituated levels during the Novel Stimulus phases and Return to Original Stimulus phases, it is unlikely that biological satiation was responsible for the initial decrements. Furthermore, stimulus specificity and dishabituation patterns were also observed in five out of six of the conditions that used a non-edible reinforcer as a constant. The broader use of the term satiation, which includes a loss of effectiveness for non-edible reinforcement, implies that once satiation occurs, the only way to counteract the effect is through deprivation. Given that antecedent stimulus changes resulted in increased responding while non-edible reinforcers were held constant within the sessions, data from the current study add to the previous literature by suggesting that this term may not be adequate for explaining decrements in operant responding.

A final purpose of the study was to examine what effect two novel antecedent stimulus changes would have on a habituated response, potentially providing clinicians with some practical options for reinstating the value of a reinforcer. Given the simplicity of the antecedent stimulus changes, these results may indeed provide potential support for some practical ways to reinstate the value of a reinforcer that has lost its effectiveness within a session, without the need to identify another reinforcer. The Research Assistant Change condition was effective in producing dishabituation for all participants, echoing a recent suggestion that having another person periodically deliver reinforcement during clinical sessions may help reinforcers remain effective (McSweeney & Murphy, 2017). In addition, the Task Stimulus Change condition resulted in stimulus specificity and dishabituation for 2 out of 3 participants (Participant 1 and Participant 2), suggesting that changing some property of a task may be another way for clinicians in the field to reinstate the effectiveness of reinforcers. Furthermore, it should be noted that the lack of dishabituation in Participant 3’s Task Stimulus Change condition may have involved other factors that could not be controlled.

Limitations and Future Research

As with any study, the current study was not without limitations. One potential limitation was that some of the data may have been affected by other MOs that arose as a product of the number and length of sessions, the setting, or the procedure itself. The study was conducted in a lab setting in order to control for as many extraneous variables as possible, such as outside auditory or visual stimuli; however, that setting may have been too novel for the participants, despite rapport building prior to the sessions. It is also possible that the FR 4 schedule was too thin for children the age of the participants in the study. Future studies might benefit from using a more naturalistic setting and a denser schedule of reinforcement in order to decrease the chance that the experiment becomes aversive to the participants.

Regarding the stimulus changes themselves, from Original Stimulus to Novel Stimulus phases, there were some procedural differences across, and, in one case, within participants that should be noted as another potential limitation. For all of Participant 1's sessions and for Participant 2's Reinforcer Change condition, the change to the Novel Stimulus phase and the return to the Original Stimulus phase was signaled; that is, the timer was stopped at the end of the Original Stimulus phase, and the instructions were delivered again at the beginning of each phase of the condition. This was modified to an un-signaled change in the stimuli to increase the likelihood that the stimulus changing in the condition, rather than the delivery of the instruction, was serving as the dishabituating stimulus. This procedural change appeared to make no difference in response patterns. Therefore, it appears the stimulus changes themselves were sufficient in producing stimulus specificity and dishabituation. Although the dishabituating stimulus may be less clear for the conditions which contained the signaled stimulus changes, those that contained the representation of the instruction could be said to have increased external validity, considering that in an applied setting, instructions or even a brief preference assessment would likely be presented again following a change in task, therapist, or reinforcer.

Another limitation, related to the manipulations made in the current study, is that although a number of stimulus changes have produced dishabituation of operant responding in the existing literature, very little is known about what specific properties of those stimuli are producing the sensitization effect. The current study made attempts to make the stimuli in the experiment as different as possible. For example, the constant task stimuli were red foam triangles, while the blocks and poker chips used in the Task Stimulus Change condition were different size, color, weight, and smoothness vs roughness from each other and from the triangles; the edible reinforcers used in the Reinforcer Change condition all varied in color, consistency, flavor, and to some degree, size and shape; and the research assistants who facilitated the task also happened to differ significantly in skin tone, hair color, and tone of voice, although this was not programmed. This limitation is perhaps most prominent in the Research Assistant Change condition because it is unclear if the research assistant changing or if the research assistant simply changing location abruptly that resulted in sensitization of the response. A future study that holds all variables of the changing stimuli constant except for a single property might help to shed some light on this problem.

On a related note, according to Thompson and Spencer (1966), stimulus changes must be significantly different from the original stimulus to produce stimulus specificity and dishabituation, but little is currently known about the necessary parameters of the stimulus changes that can result in dishabituation of an operant response. Future research investigating these parameters might consist of manipulating the intensity of extraneous stimuli shown to produce stimulus specificity and dishabituation until a stimulus generalization gradient for that stimulus emerges. More information regarding the stimulus parameters of stimuli could help make research on the subject more efficient by providing an effective starting point for researchers wishing to advance the literature.

And finally, future research should begin to study these phenomena in applied settings with clinically relevant populations. Currently, the research on how habituation functions for people with ASD is mixed (Szabo, 2014) and has been exclusively studied in the respondent paradigm. Future research should begin to investigate these phenomena as they pertain to the operant paradigm. Given the importance of reinforcement in EIBI treatments for children with ASD, a better understanding of how habituation and sensitization function for this population would be immensely beneficial and could potentially lead to more effective interventions and increased learning outcomes.

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APPENDIX: PROCEDURAL INTEGRITY CHECKLIST

Procedural Integrity Checklist		
Original Stimulus Phase		
Task	Correct (Tally)	Incorrect (Tally)
Instruction delivered at the beginning of the session		
Stimuli replenished within 2 seconds of a completed response.		
No extraneous stimuli during response intervals		
Reinforcer delivered within 3 sec of the 4^{th} response.		
No extraneous stimuli present during reinforcement interval		
Prompt ("time's up") delivered ONCE after 10 sec w/ reinforcer		
No extraneous stimuli present during change to novel stimulus condition		
Total		