FURTHER ANALYSIS OF VARIABLES THAT AFFECT SELF-CONTROL
WITH AVERSIVE EVENTS

DISSERTATION

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Abstract

The purpose of this study was to examine variables that affect self-control within the context of academic task completion by elementary school children diagnosed with autism. In the pre-assessment of study 1, mathematics problem completion was shown to be an aversive event, and sensitivity to task magnitude, task difficulty, and delay to task completion was measured. The self-control assessment assessed the effects of manipulating values of those parameters on self-control. For all participants, self-control increased as a function of one or more changes in task parameter values. In study 2, the effects of a commitment response on self-control was assessed. Results indicated that for all participants, levels of self-control were higher when the opportunity to commit to the immediate aversive event was available.
Dedication

To Stefanie, Josephine, and Kaitlyn
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Chapter 1: Introduction

Non-compliance is a commonly reported problem behavior in behavioral literature (e.g., Call, Wacker, Ringdahl, Cooper-Brown, & Beolter, 2004; Rodriguez, Thompson, & Baynham, 2010; Wilder, Harris, Reagan, & Rasey, 2007). In addition to being problematic in and of itself, non-compliance also has been shown to covary with more serious problem behaviors (e.g., Parrish, Cataldo, Kolko, Neef, & Egel, 1986). In addition, results of analogue functional analyses often identify escape or avoidance of task completion as a maintaining variable for destructive behavior (Asmus et al., 2004; Iwata et al., 1994). A study by Asmus et al. reported that of 138 individuals, 27% of those diagnosed with a developmental disability and 40% of those individuals who did not have a diagnosis were found to engage in problem behavior solely maintained by negative reinforcement.

A number of interventions for non-compliance have been discussed in the behavioral literature including differential reinforcement (e.g., Dwyer-Moore & Dixon, 2007) and noncontingent escape (e.g., O’Callaghan, Allen, Powell, & Salama, 2006). For instance, following a functional analysis that indicated a participant’s disruptive vocalizations were maintained by negative reinforcement, Dwyer-Moore and Dixon (2007) taught the participant to request breaks from task completion and social–
proximity by exchanging a “break” card. O’Callaghan et al. used noncontingent escape in the context of dental treatment to reduce five children’s disruptive behavior. Using a fixed-time (FT) schedule ranging from 15 s to 60 s, breaks (10 s in length) were provided throughout the dental procedure. One potential problem with these interventions is that they do not change how the task or aversive situation is presented. As such, stimuli associated with presentation of the task or aversive situation may continue to function as discriminative stimuli for escape behavior, which in turn results in persistence of that behavior.

One means of avoiding or decreasing these problems is to manipulate antecedent conditions instead of, or in addition to, consequences. One such intervention, behavioral momentum (e.g., Mace et al., 1988), consists of presenting demands that have a low probability of compliance within a sequence of demands that are likely to be completed. Presenting this sequence of demands in rapid succession increases the likelihood of compliance with the low probability demand.

A number of studies have assessed the effectiveness of behavioral momentum in the treatment of non-compliance and escape maintained problem behavior across a variety of situations. In an early application to human behavior, Mace et al. (1988) used a behavioral momentum procedure to increase compliance with “do” and ‘don’t” requests for five adults with developmental disabilities. Requests included simple tasks such as showing the therapist a wallet or removing one’s feet from the coffee table, as well as self-care skills such as emptying the trash and personal hygiene activities. Results indicated that when low-probability requests were preceded by a sequence of
high-probability requests, compliance was more likely. Furthermore, the procedure was effective in decreasing latency to initiate tasks as well as duration of task completion. Behavioral momentum also has been applied to latency problems associated with low-preference academic tasks (Belifore, Lee, Vargas, & Skinner, 1997; Wehby & Hollahan, 2000). For instance, Belifore et al. preceded presentation of multiple-digit multiplication problems with single-digit multiplication problems. Both participants’ latency to initiate multiple-digit multiplication problems decreased under the interspersed condition relative to presentation of multiple-digit problems alone. In another application, McComas, Wacker, and Cooper (1998) used behavioral momentum in combination with differential reinforcement of alternative behavior (DRA) and escape extinction to increase a toddler’s compliance with medical procedures (e.g., laying still and not touching his central-venous line site while it was cleaned).

Although the findings in the above studies are promising, results of other studies have suggested that escape extinction is often necessary when using behavioral momentum to decrease non-compliance, especially when individuals engage in escape maintained behavior that actively competes with compliance. For instance, Zarcone, Iwata, Mazaleski, and Smith (1994) compared the effectiveness of behavioral momentum with and without extinction on the levels of compliance and self-injury (SIB) exhibited by two adults. Results of a functional analysis indicated that both participants’ SIB was maintained by negative reinforcement. During the treatment comparison, both participants demonstrated differentially higher levels of compliance
and lower levels of SIB when extinction was in place than when behavioral momentum was the sole intervention.

A second antecedent based intervention for non-compliance is to modify the language of the prompt itself. Piazza, Contrucci, Hanley, and Fisher (1997) compared the effects of two types of prompting, directive (e.g., Brush your hair.) and non-directive (I like it when your hair is brushed.) on the levels of compliance and destructive behavior demonstrated by a young girl during hygiene routines. Both forms of prompting were combined with reinforcement (DRA for compliance during the directive prompt condition and noncontingent (NCR) during the non-directive prompt condition) and escape extinction. Results indicated that non-directive prompts produced differentially lower levels of destructive behavior and more consistent task completion than directive prompts. In a similar study, Peyton, Lindauer, and Richman (2005) compared the effects of directive and non-directive prompts in combination with escape extinction on levels of compliant and noncompliant vocal behavior exhibited by a young child. Results indicated that although compliance was high across both conditions, levels of noncompliant vocal behavior were lower in the non-directive prompt condition. In both of the above studies, escape extinction was in effect during all conditions. Therefore, it was impossible to determine the extent to which non-directive prompting alone increased compliance.

An alternative approach to treating escape maintained problem behavior is suggested by viewing these behaviors as problems with self-control. Although self-control, the opposite of impulsivity, is often considered to be related mainly to choices
involving concurrently available reinforcers (Ainslie, 1975), self-control also occurs when choices must be made between two or more aversive events. With respect to aversive events, self-control is demonstrated when, given a choice between an immediate aversive event and a delayed but relatively more aversive event, the immediate aversive event is preferred. Impulsivity is said to be demonstrated when the delayed but relatively more aversive event is preferred. Problems with self-control often occur in classrooms when demands are presented to individuals who find completing those tasks aversive. That individual must choose between complying with the demand, thus exposing him or herself to the aversive task, and engaging in some type of escape response (i.e., requesting a break or engaging in problem behavior). Although escape responses often delay task completion, they also frequently result in a worsening of the environment. This is especially true of problem behavior, which can lead to more intrusive prompting, loss of opportunity to contact positive reinforcers, and even punishers such as verbal reprimands or response cost. Despite a paucity of literature, several methods to increase self-control with aversive events found in the basic literature may be applicable to classroom situations.

One intervention to increase self-control with aversive events suggested by basic literature is manipulating the parameters of the aversive event. For instance, a 1978 study by Deluty included a series of experiments that explored the effects of changes in parameters of contingent electric shock on rats’ lever pressing within a concurrent operant arrangement. Depending upon which lever the rat pressed, one of two shock arrangements occurred that differed in (a) delay to shock presentation, (b) duration of
shock, or (c) both. Results indicated that the rats preferred (selected) shocks that either were delayed or were shorter in duration. When delay and magnitude were placed in competition (i.e., immediate but short shock versus delayed but longer shock), responding was impulsive, that is allocation favored the larger-later shock. However, when the delay to both alternatives was increased, responding switched from impulsive behavior (larger-later shock) to self-control (smaller-sooner shock). Self-control also increased following systematic increases in the duration of the delayed shock.

Similar results have been found for aversive events other than electric shock. For instance, a series of studies involving pigeons used work requirements as the aversive event (Mazur, 1996, 1998). In both studies, a variable time (VT) schedule of food delivery was interrupted either by a ratio schedule (Mazur, 1996) or a variable interval (VI) schedule (Mazur 1998). As with Deluty (1978), results indicated that self-control increased as the delay to both alternatives increased. In another study, Grusec (1968) had children choose between smaller aversive events that would occur immediately and larger aversive events that would occur following a two-week delay. Events assessed included eating unpleasant food, memorizing lines of boring poetry, spending time with an unpleasant teacher, and completing difficult tasks in front of the class. It should be noted that these events were chosen by the experimenters rather than formally assessed to determine whether they were in fact aversive. Results of a group design analysis indicated that increases in the magnitude of the delayed aversive event resulted in greater self-control.
Lerman, Addison, and Kodak (2006) examined the effects of manipulating task parameters on the self-control of two children diagnosed with autism. Two task parameters, magnitude (e.g., the number of discrete trials required) and delay were manipulated. After demonstrating preference for larger delayed tasks over smaller more immediate tasks (impulsivity), the effects of increasing the extent of the delay to both alternatives, increasing the magnitude of the delayed task, and decreasing the magnitude of the immediate task were examined. One participant demonstrated self-control when provided a choice between small immediate tasks and delayed large tasks. Self-control maintained when increases in the task magnitude for both alternatives were made and when the delay to both the immediate and delayed tasks was increased. For the second participant, increases in the delay to both immediate and delayed tasks had minimal effect and changes in task magnitude had no effect on his response allocation.

Another approach to increasing self-control with aversive events suggested by basic research is presenting the opportunity to commit to the smaller-sooner alternative before the choice is presented. Because both alternatives are temporally distal at the time of commitment, the likelihood of self-control is high. Deluty, Whitehouse, Mellitz, and Hineline (1983) examined rats’ engagement in a commitment response for a smaller-sooner shock. Across all conditions, the commitment response produced a brief shock following a 5 s delay. If the commitment response did not occur, a choice between an immediate brief shock and a long shock following a 5 s delay was presented following a “delay to choice interval.” Results indicated that as the delay to choice increased, the likelihood of commitment responses occurring also increased.
Collectively, the results of these studies suggest that manipulating the parameters of the aversive events and providing opportunities to commit to smaller-sooner aversive events may increase the likelihood of self-control. However, there are a limited number of studies. This author was unable to find any studies involving humans that examined the effects of a commitment response on self-control with aversive events, and only one study (Lerman et al., 2006) applied task parameter manipulations to socially significant human behavior. Furthermore, Lerman et al. included only two participants and the results were mixed. In light of this, further research of variables that affect self-control with aversive events is warranted. In addition to task magnitude and delay, changes in other task parameters such as task difficulty also may promote self-control and should be included in future studies. In addition, the extent to which the commitment responses increase self-control should be examined.

**Purpose of the Study**

The purpose of this study was to examine variables that affect self-control within the context of academic task completion by elementary school children. Study 1 replicated and extended the Lerman et al. (2006) study by examining the effects of manipulating task magnitude, task difficulty, and delay to task completion on self-control. In Study 2, the effects of a commitment response on self-control were examined.
Chapter 2 : Literature Review

Impulsive behavior manifests itself in many forms and is a common occurrence in daily life. For example, forgoing exercise to watch a favorite TV show, choosing to buy a new article of clothing now as opposed to saving the money for a future vacation, and forgoing regular teeth cleaning by the dentist for a visit because of a toothache are all impulsive behaviors. Impulsive behavior also occurs regularly in the classroom. Students who call out to get attention instead of raising their hand, cut in line instead of waiting for their turn, frequently ask teachers for feedback instead of waiting until they have completed their work, and forgo regular studying for an all night cramming session are all demonstrating impulsive choices.

Impulsivity is especially relevant for special educators. Many diagnoses including attention-deficit-hyperactivity disorder (ADHD), impulse-control disorder, reactive-attachment disorder of early childhood, fetal-alcohol syndrome, bipolar disorder, and William Syndrome all include impulsivity as a diagnostic criterion. In addition, individuals diagnosed with autism, Down syndrome, and brain injury are often described as being impulsive. When working with these students, special educators are frequently faced with impulsive behavior. For instance, avoidance behaviors often occur during occupational and physical therapy activities as well as academic tasks.
This is likely because the natural outcome of these activities, improved gross or fine motor activities or good grades, is often delayed.

Impulsive behavior has been linked with a number of poor outcomes. For instance, Shoda, Mischel, and Peake (1990) found significant relations between self-control demonstrated on an experimental task as a preschooler and parent ratings of self-regulation, intelligence, and ability to cope when the participants were adolescents. In addition, the results correlated significantly with both verbal and quantitative SAT scores. In another study, Kirby, Winston, and Santiesteban (2005) measured the extent to which undergraduate college students discounted the value of future rewards due to the delay to those rewards. When the results of this task were compared with the grade point averages, students who responded impulsively on the task (discounted values of future rewards at relatively short delays), performed worse academically than students who did not respond impulsively.

Impulsivity is a construct that outside of the behavioral literature is often defined by describing various forms of behavior considered impulsive. For example, the Diagnostic and Statistical Manual IV (DSM-IV) describes impulsivity as “impatience, difficulty in delaying responses, blurting out answers before questions have been completed, difficulty awaiting one’s turn, and frequently interrupting or intruding on others to the point of causing difficulties in social, academic, or occupational settings” (American Psychiatric Association, 2000, p.86). This topographical definition focuses on the form of the behavior and provides no information as to the reasons why it is occurring. Although many behaviors look alike, it is quite possible and often the case
that they occur for different reasons. For example, raising one’s hand to ask the teacher a question and raising one’s hand to ask permission to use the restroom appear identical; however, the outcomes are different and are not substitutable. Because of this, interventions that are based on a behavior’s form instead of its function are likely to fail, increasing reliance on more intrusive interventions such as punishment.

An alternative approach to using topographical descriptions is to define behavior according to its function. There are several advantages to this approach. Most importantly, as noted above, identifying the function of a behavior informs treatment. That is, when the function of the behavior is known, it is possible then to develop interventions that match the function, increasing the likelihood of treatment success.

Because behaviors that look different can produce similar outcomes, an intervention that addresses that function should successfully treat both behaviors. For instance, calling out in class and walking around the classroom often produce a similar outcome, teacher attention, despite appearing very different. If producing teacher attention is the function of both of these behaviors, then an intervention that reinforces hand raising with teacher attention will likely treat both inappropriate behaviors.

From a practical standpoint, impulsivity can be conceptualized behaviorally as behaving in ways that produce more immediate outcomes. For example, the child who calls out in class is likely to get the teacher’s attention sooner than if he had raised his hand and waited for the teacher to call his name. In behavioral research, impulsive behavior is usually defined as choosing a smaller or relatively low-quality immediate reward over a larger or relatively high-quality delayed reward (Ainslie, 1975). In
contrast, self-control is exemplified as choosing the larger delayed reinforcer over the more immediate reinforcer. These definitions keep impulsivity and self-control as opposites. That is, as impulsivity decreases, a corresponding increase in self-control occurs.

Temporal discounting is a term used to describe the effect that delay has on the relative value of a consequence. In general, as the time between a response and its consequence increases, the effectiveness of that consequence weakens as a function of the delay. In the case of reinforcement, a reinforcer that is delivered immediately is likely to have a greater affect on behavior than one that is delayed. This decaying of reinforcer effectiveness as a function of time has been described as the “delay-of-reinforcement gradient” (Catania, Sagvolden, & Keller, 1988). Depending upon the severity of the delay-of-reinforcement gradient, more or less impulsive behavior will be demonstrated. Severe and steep delay-of-reinforcement gradients select and strengthen impulsive behavior. As a result, when an individual with a severe and steep delay-of-reinforcement gradient is provided with a choice between a smaller-sooner reinforcer and a larger-later reinforcer it is likely that impulsive responding will occur.

Given the prevalence of impulsivity and poor outcomes for individuals who engage in impulsive behavior, there is a need for effective means of assessment and treatment. If practitioners and educators are able to teach a repertoire of self-control at an early age, it is possible that the likelihood of these poor outcomes will decrease.
Methods of Assessment

There is a variety of ways that impulsivity is assessed in both basic and applied settings. However, in general, all of the methods have the same core components; a choice is made between two alternatives, followed by a prereinforcer delay, and then reinforcer access. Frequently a post reinforcer delay is introduced in order to hold trial lengths constant irrespective of choice. While other procedural variations exist, two common methodologies include those referred to as temporal or delay discounting and delay-of-gratification. In temporal discounting paradigms, an initial choice is made between two concurrently available alternatives, a smaller-sooner reinforcer and a larger-later reinforcer. Once the choice is made, the participant has usually committed to that choice (e.g., Chung & Herrnstein, 1967).

Frequently temporal discounting procedures involve a parametric analysis in which values of delay, magnitude, or both are manipulated using either a fixed (e.g., Ragotzy, Blakely, & Poling, 1998) or adjusting procedure (e.g., Crean, de Wit, & Richards, 2000; Lagorio & Madden, 2005; Madden et al., 2004; Mitchell & Rosenthall, 2003). The main difference between these procedures is how the values are adjusted. In the fixed procedure, the values of the parameter being manipulated change in a pattern determined by the experimenter. This often is a systematic increase or decrease across all of the tested values. An adjusting procedure differs in the sense that the participant’s choices determine the parameter manipulation for subsequent trials. For example, if the participant chooses the larger-later alternative, the delay would be increased on the subsequent trial. However, if the participant chooses the smaller-
sooner alternative, the delay would be decreased on the subsequent trial. Because the parameters tested during an adjusting procedure are determined by the participant, not every value of the parameter will necessarily be tested.

Delay-of-gratification procedures differ in that the dependent variable is time the participant can tolerate waiting rather than the alternative chosen (e.g., Grosch & Neuringer, 1981; Mischel, Ebbesen, & Raskoff Zeiss, 1972). Thus, a high-preference item is available contingent upon waiting for a predetermined time interval, whereas a low-preference item is available at any time. Because the participant has the option to defect to the low-preference alternative at any time, delay-of-gratification procedures have been described as measures of what is commonly referred to in lay terms as “will power.”

Despite measuring impulsivity under different experimental contingencies (e.g., initial choice versus ability to sustain choice) comparisons of performance in temporal discounting and delay-of-gratification paradigms have shown rates of discounting do not differ significantly (Reynolds, de Witt, & Richards, 2002), supporting the views of other researchers that these are equivalent processes (Johnson & Bickel, 2002; Schweitzer & Sulzer-Azaroff, 1995). However Reynolds et al. also noted that as the delay interval increased in the delay-of-gratification procedures, defections also increased suggesting that initial choice and ability to sustain choice may in fact be different.

**Methodological Concerns**

One area of concern that has arisen with respect to measuring impulsive behavior is issues translating the procedures used with nonhuman participants to
research involving humans. In basic research, various food reinforcers are associated with the choice alternatives and forced choice trials are incorporated to expose the subjects to the contingencies for each alternative. In addition, assessments are conducted until steady state responding is obtained. Although these are common components in research involving nonhuman participants, they each present logistical issues when conducting research with humans. As such, discounting tasks involving humans normally (a) incorporate hypothetical rewards as opposed to real rewards, (b) do not include forced choice trials, and (c) do not obtain steady state responding. The most obvious reason for these procedural changes when working with humans is simply the practicality; it would be impractical to deliver large sums of money to a large group of participants even for forced choice trials let alone every trial. In addition, the time commitment to obtain steady state responding at every value tested might be longer than many participants are willing to make. Because of concerns resulting from these changes, several researchers have assessed their effects on the outcome of assessments of impulsivity.

When hypothetical rewards are used as opposed to real rewards, the paradigm shifts from making choices based on actual consequences to making choices based on how one might behave if those consequences were real. If the participant does not have a history of making similar choices outside of the experimental context, it is possible that it is not an accurate analogue. For example, many people rarely have had to choose between forgoing $1000 delivered today in exchange for $10,000 delivered in one year yet this is a common choice in discounting tasks. One of the ways researchers have
addressed the issue of hypothetical rewards is to inform participants during the instructions that one of the trials will be randomly selected and the reward they choose for that trial will be delivered. This procedure was used by Madden et al. (2004) who examined the effects of hypothetical rewards on a discounting task completed by college students. Using an adjusting delay procedure, college students made choices between purely hypothetical rewards or between rewards of which one randomly selected choice would be real. That is at the end of the experiment, the participant would actually receive one of his/her chosen rewards. The comparison was made twice, first using a group design in order to control for sequence and carry over effects and then using a single-subject design to increase internal validity. The results of the group comparison did not find a statistically significant difference between the results of the assessment with the different types of rewards. The results of the within subject comparison were the same as those from the group design, that is, there was no difference between the assessments using different types of rewards. Similar results were found in studies by Johnson and Bickel (2002) and Madden, Begotka, Raiff, and Kastern (2003).

The stated purpose of the study was to test the difference between temporal discounting procedures that use real and hypothetical rewards; however, the real reward condition in this experiment included only one reward. Instead of every trial being a choice between real alternatives, it is actually a prospect choice in which any trial may be the one that results in the delivery of an actual reward. As a result, these data provide no information as to whether a similar outcome would be obtained if all of the choices had been real. A comparison study that used all real rewards was conducted by Lane,
Cherek, Pietras, and Tcheremissine (2003). Sixteen adults completed a discounting task using hypothetical rewards and real rewards where a reward was delivered for every choice. Although results indicated that discounting rates differed across conditions, these results may have been an artifact of the procedures. Specifically, the delay to the actual rewards was not manipulated; instead, the delay to the delivery of points that could later be exchanged for rewards was manipulated. Previous research has shown in both pigeons and humans, that delay to the point of exchange affects responding, not delay to point delivery (Hackenberg & Vaidya, 2003; Hyten, Madden, & Field, 1994; Jackson & Hackenberg, 1996).

The problems caused by the use of hypothetical rewards may be exacerbated when discounting tasks do not incorporate forced choice trials or obtain steady state responding. Both of these procedures create a behavioral history within the experimental context that can affect later responding. A study conducted by Lagorio and Madden (2005) examined the effects of steady state assessment, the incorporation of forced choice trials, and the use of hypothetical rewards versus all real rewards when conducting discounting tasks with 6 college students. To control for sequence effects that may occur from receiving real rewards for their choices prior to making choices that involve hypothetical rewards, all participants completed the task that incorporated hypothetical rewards first. An adjusting delay procedure was completed once per day, five days per week. When comparisons were made between the discounting rates obtained on the first day of the assessment with those obtained after repeated exposure, there was no systematic difference, that is repeating the task until steady state
responding was obtained did not change the results of the assessment. In addition, there was no consistent difference between the results obtained with hypothetical and real rewards. This was true despite the use of forced choice trials and obtaining steady state responding. The authors discussed several limitations with the procedures of these comparisons. First, when the tasks involved all real rewards the choice trials overlapped. That is, when the later alternative was chosen that delay interval was not completed prior to the next trial. Because a delayed reward was already scheduled to be delivered, this may have increased the likelihood of an impulsive choice. In addition, obtaining the delayed real rewards required the participant to return to the laboratory to purchase the item from the store, which may have been viewed as increased response effort for the delayed alternative relative to the immediate alternative.

Collectively the results of these studies provide preliminary evidence that suggests the incorporation of hypothetical rewards does not appear to affect the results of temporal discounting tasks. In addition, use of forced choice trials or steady state responding criteria may not be necessary. However, further investigation is still warranted. Individuals with disabilities, brain injuries, or children may perform differently than the college students who participated in these studies. These individuals may not have extended histories with delayed outcomes on which to base their current choices, as such, their performance might be affected by the inclusion of forced choice trials, or repeated exposure to the experimental conditions. For instance, Dixon et al. (2005) found that individuals with acquired brain injuries might have performed differently on a delay-discounting task when it involved choices related to activities and
items they contacted in their daily lives. In addition, Grosch and Neuringer (1981) found that pigeons exhibited lower levels of self-control following a history of delayed reinforcement on an intermittent schedule. On the other hand, Grusec (1968) successfully measured the impulsive choices of third-grade children using hypothetical rewards and one random real reward. Further investigation of the effects of forced choice trials and steady state responding with other populations is warranted.

**Assessment as a Diagnostic Tool**

The diagnosis of most disorders usually consists of a topographical assessment in which behaviors exhibited by an individual are matched to a list of characteristic symptoms. This process is often completed using subjective measures such as rating scales and interviews with caregivers. An alternative approach to this method is the use of assessments that objectively measure the occurrence of functionally defined characteristic behaviors. In the case of impulsive behavior, discounting tasks offer an approach for objectively measuring whether or not, and to what extent, an individual engages in impulsive choice. Several studies have examined this role of discounting tasks.

One area of support for discounting rates as a measure of ADHD comes from the nonhuman literature. The spontaneously hypertensive rat (SHR) has been studied as a potential rodent model of ADHD, because it engages in relatively higher levels of impulsive behavior than the Wistar-Kyoto rat (WKR; e.g., Adriani, Caprioli, Granstrem, Carli, & Laviola, 2003; Fox, Hand, & Reilly, 2008). Adriani et al. compared the performance of SHR and WKR on a temporal discounting task using a group design.
Choices between a single food pellet available immediately and 5 food pellets available following a delay were assessed at progressively increasing delay values ranging from zero to 100 s. Although the results did not find a significant difference between the two strains, a subgroup of the SHRs was found to discount delayed rewards significantly more than the WKRs. In a similar study, Fox et al. compared SHRs and WKRs using 1 food pellet available immediately and 3 food pellets available at delays ranging from 1 s to 24 s. Several arrangements were assessed including progressively increasing delay values, progressively decreasing delay values, and random delay values. Results indicated that although the difference was smallest during the progressively increasing delay condition, irrespective of the presentation format SHRs discounted delayed rewards significantly more than the WKRs. Several procedural differences most likely account for these disparate results. First, Adriani et al. used progressively increasing delay values, which may have promoted self-control (see discussion on progressive delays below). In addition, Adriani et al. used a fixed session length. As a result, opportunities for delayed reinforcer delivery decreased as the delay to the larger reinforcer increased. This potentially biased responding towards the smaller-sooner alternative. On the other hand, Fox et al. held all sessions at 36 trials, maintaining equal opportunities to contact reinforcement irrespective of choice allocation.

Using a group design, Crean et al. (2000) compared the results of an adjusting delay discounting task for 24 individuals with psychiatric disorders. Using criteria for their specific diagnoses, half of the participants were categorized as high-risk for being impulsive whereas the other half were categorized as low-risk for being impulsive.
Results indicated that the high-risk group discounted delayed rewards significantly more than the low-risk group.

A similar study conducted by Dixon et al. (2005) used a group design to compare the results of a discounting task obtained for 19 adults with an acquired brain injury and 23 college students who did not have an acquired brain injury. The results of the first experiment indicated that those participants with an acquired brain injury discounted delayed rewards significantly more than the control group. However, the authors hypothesized that these results may be due to the values and delays used in the discounting task. A follow-up experiment incorporated lower monetary values and shorter delays. The results of this comparison differed from the previous experiment. Not everyone in the acquired brain injury group discounted delayed rewards greater than those individuals in the control group. In fact, some individuals with an acquired brain injury demonstrated greater self-control than individuals in the control group. Although the authors attempted to make the discounting task more real for those individuals in the acquired brain injury group, it is possible that this goal was not met. The second experiment still incorporated money, something that is rarely used in a treatment facility.

In a 2005 study, Neef, Markel et al. compared the results of a reinforcer dimension assessment for 34 students with ADHD and 24 students without ADHD. A computer program measured children’s time allocation between two alternative sets of mathematics problems that were associated with different reinforcer dimensions. First, sensitivity to high and low values of reinforcer rate, quality, delay, and response effort
was assessed. Next, those dimensions were placed in direct competition (i.e., rate versus quality, rate versus effort, quality versus effort, quality versus immediacy, immediacy versus effort) and compared in a single-subject design adapted from the brief functional analysis methods (Cooper, Wacker, Sasso, Reimers, & Donn, 1990). The results of group and within subject comparisons indicated that reinforcer delay was the most influential reinforcer for children with ADHD irrespective of whether they were taking stimulant medications (54% with medication, 48% without medication) whereas reinforcer quality was the most influential dimension for those children not diagnosed with ADHD. In addition, the children diagnosed with ADHD were more sensitive to response effort than those who were not diagnosed with ADHD, avoiding difficult problems more.

A 2006 study by Hoerger and Mace used a group design to compare the results of a reinforcer dimension assessment for children at-risk for and not at-risk for ADHD on a discounting task and then linked those results to classroom behavior. Thirty young boys completed an assessment that measured sensitivity to reinforcer delay and response effort by providing choices between smaller-sooner and larger-later reinforcers and then easy versus hard mathematics problems. For the classroom observation, data were collected on gross motor movement, inattention, inappropriate use of materials, and inappropriate vocalizations. Results indicated a significant main effect between the groups for reinforcer delay and response effort. That is, the group at-risk for ADHD made more impulsive choices than the comparison group. In addition, the group at-risk for ADHD made significantly more choices for the easy mathematics problems than the
control group. When rates of behaviors observed in the classroom were compared, the test group showed higher rates than the control group on all measures. Significant differences were observed for gross motor movement, inappropriate vocalizations, inattention, and inappropriate use of materials. Furthermore, a comparison of results of the computerized assessment with those from the Conners’ rating scale, a common tool in ADHD diagnosis, indicated that the computerized assessment was slightly better at predicting which participants were at risk for ADHD.

The four studies discussed above illustrate the potential utility that assessments of impulsivity have as diagnostic aids. However, several areas still need to be addressed. First, there are only a small number of these studies and they each used different procedures, therefore further replication is needed. In addition, some of these studies are time consuming. For example, the assessment used in the Neef, Bicard, Endo, Coury, and Aman (2005) study requires several days to complete due to the use of 24-hour delays. Although objective measures of impulsivity should be preferred to subjective ones, this extensive assessment time is likely to decrease adoption of these procedures due to the relative ease with which a rating scale can be completed. A second area that requires further investigation is the linking of these assessments to behavior observed in the natural environment. With the exception of Hoerger and Mace (2006), these assessments focus solely on behavior within an analogue setting and may not be reflective of behavior outside of that context. Finally, it would be useful to determine whether these assessments can be used for determining treatment success.
For example, would measurements conducted before and following self-control training differ?

**Interventions for Impulsive Behavior**

**Progressive Delay.** One of the simplest techniques designed for decreasing impulsive behavior is the use of a progressive delay. Initially, a choice between small and large reinforcers is provided when there is little or no delay to either alternative. Under these conditions, choice allocation is likely to be towards the larger reinforcer as there is no delay to reduce its relative value. For example, a parent might ask a child to choose between one cookie available immediately and three cookies available immediately. Once consistent choice of the larger reinforcer is established (i.e., the three cookies), a delay is introduced and then systematically increased while maintaining choice allocation towards the larger reinforcer. In the example with the cookies, the single cookie will still be made available immediately; however, choosing the three cookies will require a brief wait before the cookies are delivered. Through repeated success at contacting delayed reinforcement, progressive delays slowly strengthen self-control.

Mazur and Logue (1978) used a progressive delay procedure to increase the self-control of pigeons. Initially, impulsive behavior was demonstrated by having pigeons choose between 2 s of grain available immediately and 6 s of grain available following a 6 s delay. Next, the delay to both alternatives was made 6 s, which resulted in the pigeon’s response allocation switching to the larger reinforcer. Finally, the delay to the smaller-sooner reinforcer was decreased across trials until there was no delay.
Throughout the progressive delay procedure, the pigeons continued to demonstrate self-control, that is, they continued to choose the larger-later reinforcer. In addition, when compared with a control group that was not exposed to the progressive delay procedure, the experimental group demonstrated significantly more pecks on the key associated with the larger-later reinforcer than the control group.

In a study by Schweitzer and Sulzer-Azaroff (1988), a progressive delay was used to increase the self-control of 6 young children who were described as impulsive and hyperactive. Following a task parameter assessment in which the children’s indifference points were established, a training phase was implemented. During training, the delay to the larger reinforcer was increased from an initial value of zero seconds by 5 s increments. Throughout the training phase, almost all participants chose the larger-later reinforcer exclusively. Following training, the children’s indifference points were reassessed. Results indicated that 3 of 5 students chose the larger-later reinforcer at delays greater than training delays. In addition, no indifference point was established for 3 children because it was higher than those values tested during the post assessment. Several explanations could account for the increase in self-control. First, it is possible that the progressive delays helped to shape and strengthen an activity that the child engaged in during the wait time (i.e., an intervening activity). For example the children may have formed “rules” related to the delay and then stated them covertly. In addition, the lights on the apparatus that signaled the trials may have functioned as a conditioned reinforcer for choosing the larger-later alternative. One limitation with this study was the brief delays assessed. At the end of the training phase, the delays only
ranged from 20 s to 65 s; however, this phase was ended early due to the impending end of the school year.

Not only are progressive delays effective in increasing self-control, but they have shown to be preferred over delays of a fixed duration. Similar to academic tasks in a classroom situation, physical therapy (PT) usually produces large long-term benefits but little immediate reinforcement. Therefore, forgoing participation in PT to engage in some other immediately reinforcing activity is an impulsive choice. In a study by Dixon and Falcomata (2004), an adult with an acquired brain injury engaged in low levels of holding his head upright. During a natural baseline, an initial value was established by measuring the duration of head holding with no programmed consequences. Next, impulsive behavior was measured by providing a choice between 10 s of access to a DVD now versus 30 s of access to a DVD contingent on head holding for a delay length of 160 s (i.e., 10 times the natural baseline mean). During self-control training, three choices were provided: (a) the smaller reinforcer immediately, (b) the larger reinforcer contingent on head holding for the duration of a progressively increasing delay, and (c) the larger reinforcer contingent on head holding for the duration of a fixed delay. Results indicated not only a consistent shift in allocation from the smaller-sooner reinforcer to the response-contingent larger-later reinforcer (i.e., self-control), but preference for the progressive delay condition remained even when delays surpassed those of the fixed delay condition. These results indicated preference for progressive over fixed delays, an increase in self-control, and an increase in engagement in a low-preference activity.
Taken together, these studies suggest progressive delay is a viable approach to decreasing impulsivity. However, these data should be interpreted with caution. There is limited research that has used progressive delay as a stand-alone intervention. In addition, the existing studies only assessed relatively short delays. As a result, progressive delays may best be used as part of a treatment package with interventions such as intervening activities and manipulations in reinforcer and response dimensions as discussed below.

**Intervening Activity.** Intervening activities are often used as a means of filling the gap between the choice and the delivery of the later reinforcer. From a procedural standpoint, once the initial choice has been made, the individual is then provided access to an activity to engage in during the delay to the chosen alternative.

Grosch and Neuringer (1981) conducted a series of experiments with pigeons that tested whether (a) intervening activities increased tolerance for delay, (b) engagement in an intervening activity would persist in the absence of reinforcement, (c) attending to various stimuli would differentially affect responding, and (d) reinforcement history would influence self-control. In all conditions, a delay-of-gratification procedure was used. If the pigeon pecked a lighted key during the delay interval, access to a low-preference grain was delivered. If the pigeon did not peck the lighted key, at the end of the delay interval, high-preference grain was delivered. Results indicated that when pigeons were provided with an intervening activity in the form of a second pecking key located at back of the chamber, self-control increased. In addition, engagement in this intervening activity maintained after reinforcement (e.g.,
delivery of a 3rd type of grain) was discontinued. Differential results were obtained when various stimuli were presented during the delay interval. For instance, when a house light that had previously been paired with reinforcement was presented during the delay interval, self-control increased. When a different house light, which had been paired with time out from reinforcement, was presented during the delay interval, no changes in levels of self-control were not observed. However, illumination of the food hopper during the delay interval resulted in a decrease in self-control. When brief access to the high-preference grain was provided prior to the session, attending towards the delayed reinforcer increased and self-control decreased. In addition, results indicated that (a) a history of receiving reinforcement following a brief delay produced high levels of self-control, (b) a history of not receiving the high-preference grain after the delay but accessing the low-preference grain for key pecks resulted in low levels of self-control, and (c) a mixed history resulted in medium levels of self-control.

Collectively, these results suggest that intervening activities are a viable means of increasing self-control. Some attending responses appear to be as effective as key pecks. In addition, engagement in intervening activities will persist in the absence of externally delivered reinforcement, suggesting that engagement in the intervening activity produces automatic reinforcement. Finally, these results illustrate that history of obtaining delayed reinforcers affects self-control.

Several applied researchers have examined intervening activities as an intervention for impulsivity. For example, Mischel et al. (1972) used a group design to examine the effects of various intervening activities on preschoolers’ self-control using
a delay-of-gratification paradigm. The experimenter provided an initial choice between two small edibles. Once the child selected, he/she was informed that he/she could consume the low-preference item (e.g., the item he/she had not chosen) now or the high-preference item after a delay. During the delay, the experimenter left the room, but if the child rang a bell, the experimenter returned and provided access to the low-preference item. If the child did not ring the bell, the experimenter returned to the room after 15 minutes and provided access to the high-preference item. Intervening activities compared included access to a toy and various instructions such as “think fun thoughts”, “think sad thoughts”, and “think about the reward”. Results indicated that the children who were provided with an intervening activity waited longer than those who were not provided with an intervening activity. In addition, instructions to “think fun thoughts” produced a longer mean duration of waiting than access to a toy while instructions to “think sad thoughts” or “think about the reward” produced shorter durations of waiting.

The effects of various intervening activities were compared in a study by Binder, Dixon, and Ghezzi (2000). The study included 3 children, ages 3 to 5, diagnosed with ADHD. Baseline levels of waiting were established by having the child wait as long as they could before consuming a small edible item. Next, preference for smaller-sooner over larger-later reinforcers was demonstrated using a concurrent choice arrangement. During self-control training, a multielement design was used to compare the continuous recitation of a rule related to the delay (“If I wait a little longer I will get the bigger one.”) with an activity in which the participants named pictures on flashcards. In the final phase, an alternative condition was conducted in which either a random statement
(“Black, table, wobble, green.”) was repeated continuously (1 participant) or no activity (2 participants) was introduced. Results indicated that preference for the larger-later reinforcer remained high regardless of the intervening activity. In addition, during the alternative activity, preference for the larger-later activity remained high, including the participants for whom there was no intervening activity. These results support those of Mischel et al. (1972) in that the form of the intervening activity is not an essential characteristic. In addition, the results for participants who demonstrated self-control after the intervening activity was removed, suggest that self-control may maintain after training with an intervening activity. However, these results should be interpreted cautiously as the longest delay assessed was 51 s. In addition, the instructions provided to the students described the activities as a “game,” which may have affected performance based upon their histories of playing games.

The results of Mischel et al. (1972) suggest that the relative preference (e.g., “thinking sad thought” is likely a low-preference activity relative to “thinking fun thoughts”) for an intervening does not affect whether it increases self-control; however, some tasks appear to be more effective than others. In a 2003 study, Dixon, Horner, and Guercio increased the self-control of a 21-year-old male with an acquired brain injury using a low-preference physical therapy activity, holding his hand open and away from his body. After establishing baseline durations of hand opening, a choice arrangement was established to assess self-control. The larger-later alternative consisted of access to a preferred cartoon for 3 s contingent upon completing a hand opening exercise for 190 s. The smaller-sooner alternative consisted of 15 s of access to the cartoon independent
of the hand opening exercise. Initially choice allocation was towards the smaller-sooner reinforcer without the response contingency. While using the hand opening activity as an intervening activity, a progressive delay procedure was implemented. As a result, allocation switched towards the larger-later reinforcer contingent on the hand opening exercise. This shift in allocation produced not only an increase in self-control, but also a shift towards engagement in a low-preference activity. As a result, duration of hand opening increased from a mean of approximately 27 s to 190 s, which met the performance goal. Several limitations exist with this study. For instance, there was only one participant, the terminal delay of 190 s was rather short, and there was no demonstration that self-control generalized to physical therapy sessions or other situations outside of the study.

In a similar study, Dixon et al. (1998) increased the self-control of 3 adults with disabilities using an across participants multiple baseline design. Behaviors targeted for increase included manipulating activity materials, staying in an assigned seat, and continuous exercise. Using the targeted behaviors as an intervening activity, a response requirement, and the progressive delay requirement for the larger reinforcer all participants’ allocation switched towards the larger-later reinforcer. However, only 2 of the 3 participants met their target delay duration. For the third participant, although an increase in self-control was observed; greater success may have been achieved had a higher probability response been used as the intervening activity.

Intervening activities also have shown to be effective in simultaneously increasing the self-control of multiple individuals. In a study by Dixon and Holcoumb
(2000), 6 adults with dual-diagnoses participated in self-control training. The participants were divided into two groups of three and a changing criterion within a multiple baseline across groups design was used to assess the intervention. Throughout training, all choices between smaller-sooner (3 points) or larger-later (6 points) reinforcers had to be unanimous otherwise all group members received the smaller-sooner reinforcer. All token economy points earned were traded in immediately following the completion of the session. Thus, the delay manipulated was to the back-up reinforcer not the points. The intervening activity used during the assessment was a cooperative task of sorting cards into piles. If any participant stopped working for 5 s the timing of the delay stopped. Following measurement of baseline durations of cooperative task completion, group preference was established for the immediate smaller reinforcer with no work requirement over the larger-later reinforcer delivered contingent upon the group engaging in the task for the entire length of the delay. During self-control training, the delay to the response-contingent larger-later reinforcer was reduced to zero and then systematically increased following each successful session. Results indicated that both groups increased duration of cooperative task completion (mean durations were 300 s and 720 s for groups one and two respectively) and preference for the larger delayed reinforcer. Although this study suggests that intervening activities can be used to increase the self-control of a group of individuals at one time, there are several limitations. First, there was no demonstration that the groups would pick the larger-later reinforcer in different situations (e.g., a different task). In addition, the authors did not measure whether group performance generalized to
individual situations. It is possible that social contingencies such as peer pressure maintained self-control and that once this contingency is removed the participants would once again respond impulsively.

Given the relative success of intervening activities as a means of increasing tolerance for delay, several studies have asked if people prefer having access to intervening activities. Dixon and Cummings (2001) measured the preference of 3 children with autism for intervening activities within a concurrent fixed duration/progressive duration schedule design. All participants engaged in severe problem behavior and received in home services. The intervening activity assessed for all children was a matching-to-sample task. When given a choice between three conditions, (a) a smaller-sooner reinforcer (b) a progressively delayed larger reinforcer with no intervening activity, and (c) a progressively delayed response-contingent larger reinforcer, all participants preferred the intervening activity. In addition, rates of problem behavior were near zero in the intervening activity condition, relative to high levels during trials in which the participants were forced to sample the delayed reinforcer with no intervening activity. A strength of this study is that it demonstrated a corresponding decrease in an untargeted problem behavior when choice of the intervening activity was provided. However, as with other studies, the delays assessed during treatment were short (all less than 120 s) and generalization of treatment gains was not demonstrated.

A 2003 study by Dixon, Rehfeldt, and Randich used similar procedures to measure the preference of 3 adults with mental retardation for intervening activities. As
with the previous study, all participants showed an increase in self-control. Two participants preferred the condition with the intervening activity (putting cubes in a basket). For the one participant who did not prefer the intervening activity, the authors indicated that he attempted to interact with the experimenter, an activity that may have functioned as an intervening activity. One notable weakness of this study was the extent of the delays assessed with the intervention in place. Although the goal of the study was to assess preference for intervening activities and therefore sessions were stopped after a 20% difference between the two conditions, delays assessed were very short, at most 20 s. However, this study incorporated 2 participants with little or no verbal communication, suggesting that verbal communication is not a prerequisite for self-control.

As indicated above, the research on intervening activities has shown them to be an effective means of treating impulsive behavior. However, not all data support this finding. In a 1995 study, Schweitzer and Sulzer-Azaroff found that the introduction of activities such as music and toys did not increase the choice of delayed rewards in young boys diagnosed with ADHD. One notable difference between this study and those discussed above is the absence of a response requirement. Each of the Dixon and colleagues studies used a response requirement; therefore, reinforcer delivery was predicated on engagement in the intervening activity. On the other hand, in the Schweitzer and Sulzer-Azaroff study, children were free to engage or not engage in the activity.
In summary, the research on intervening activities has shown them to be an effective means of treating impulsive behavior. The intervening activity does not have to be preferred nor related to rules regarding the delay. In addition, it appears that given a choice, people tend to prefer an intervening activity to no activity. Finally, intervening activities can be applied within a group arrangement to increase engagement in a cooperative task. Several questions remain regarding intervening activities. First, it would be beneficial to increase our understanding of the function of the intervening activity. For example, it is possible that the intervening activity bridges the delay to the later reinforcer, similar to how tokens bridge delays to terminal reinforcers. However, the intervening activity also may also distract the individual from the delay. Assessing the function and an individual’s preference for a specific function of the intervening activity may increase the likelihood of treatment success at longer delay durations.

Another area that still requires research is whether a preferred activity is more effective than a non-preferred activity. Whereas studies such as Dixon, Horner, and Guercio (2003) and Mischel et al. (1972) suggest that various activities will have varying effects, Binder et al. (2000) suggest otherwise. One consistent limitation across these studies was the relatively brief delay durations assessed. Although many delays within the natural environment are brief (e.g., waiting for the teacher or caregiver attention) other delays are much longer (e.g., waiting to have a quiz graded). Most importantly, with the exception of Binder et al. (2000) that showed some response maintenance when the intervening activity was removed for 2 participants, none of these studies address the generalization of self-control.
**Competing Reinforcer Dimensions.** The matching law is a mathematical equation that states that the distribution of responses between two concurrently available responses is proportional to the reinforcement received on those alternatives (Herrnstein, 1961). Subsequently, the matching law has been expanded to involve reinforcer dimensions other than rate including magnitude (Green & Snyderman, 1980), quality (Hollard & Davison, 1971), and delay (Chung & Herrnstein, 1967; Green & Snyderman, 1980). Because the generalized matching law accounts for reinforcer dimensions such as magnitude and delay, the composites of the definition of impulsivity, it provides a strong foundation for designing interventions. For instance, manipulations in various reinforcer or response dimensions so that they compete with reinforcer delay may promote self-control. A number of studies have examined the application of matching theory to impulsive behavior and the use of competing reinforcer dimensions to promote self-control.

Chung and Herrnstein (1967) extended the matching law by introducing reinforcer delay. Pigeons could respond on two keys during a concurrent variable interval (VI) 60 s schedule. During the baseline phase, the delay associated with reinforcer delivery for both keys was held equal. In the experimental condition, pecks on the left key resulted in reinforcement following either an 8 s or 16 s delay, whereas pecks on the right key resulted in reinforcement following a delay ranging from 1 s to 30 s. Results indicated that changes in the delay for the right key produced changes in responding for both keys. For example, increasing the delay for the right key produced
decreased responding on that key and increased responding on the left key. In fact, the relative frequency of responding matched the relative immediacy of reinforcement.

One of the earliest studies to extend the matching law to education settings was by Neef, Mace, Shea, and Shade (1992). This study examined the effects of reinforcer rate and quality on the response allocation of three females ages 14 to 18 diagnosed with severe emotional or behavior disorders by measuring response allocation between two piles of mathematics problems. One pile of mathematics problems produced either nickels or program money on a VI 30 s schedule and the second pile produced the same reinforcer on a VI 120 s schedule. During the second phase, a high-quality reinforcer (either nickels or program money, determined by a preference assessment) was delivered on a VI 120 s schedule whereas a low-quality reinforcer was delivered on a VI 30 s schedule. Results indicated that when reinforcer quality was held equal, response allocation favored the richer schedule of reinforcement. When reinforcer quality was unequal, 2 participants switched their allocation, responding more on the mathematics problems associated with higher quality reinforcement.

In 1993, Neef, Mace, and Shade extended the previous study by incorporating reinforcer delay, which tests for impulsive behavior. Two teenage females with developmental disabilities participated and procedures were similar to those of Neef et al. (1992). When delay to reinforcement was held equal and rate of reinforcement (VI 60/120 or VI 30/120) differed across alternatives, both participants’ allocation favored the richer schedule of reinforcement. When the richer schedule resulted in delivery of backup reinforcers at 1, 2 or 3-week delays, both participants’ allocation switched,
favoring the mathematics problems associated with a leaner reinforcement schedule and immediate access to back up reinforcers. When each of the dimensions were then put in direct completion (e.g., equal delay and quality but unequal rate, delayed high-quality on a rich schedule versus immediate low-quality on a lean schedule, immediate low-quality on rich schedule versus delayed high-quality on lean schedule) 1 participant’s responding was most sensitive to immediacy, that is she chose immediate reinforcer delivery over the other dimensions (i.e., impulsive responding), but the other participant chose alternatives based on reinforcer quality.

Neef, Shade, and Miller (1994) extended earlier work by designing a reinforcer dimension assessment using brief functional analysis methodology (Cooper et al., 1990). The assessment measured the effects of reinforcer delay, rate, quality, and response effort on the response allocation of 6 students with emotional and developmental disabilities. Using allocation of time between concurrently available sets of mathematics problems, preference for high or low values of each dimension was assessed. For example, one choice was working for reinforcers delivered now or reinforcers delivered after a 24-hour delay. Next, across six conditions, each dimension was placed in direct competition with the other dimensions. For example, low-quality reinforcers delivered immediately versus high-quality reinforcers delivered following a 24-hour delay. The results indicated reinforcer delay was the most influential dimension for 2 participants and influenced the behavior of 3 participants to a lesser extent. Because this methodology measures sensitivity to reinforcer delay (i.e., impulsive choice), it provides a possible mechanism for diagnosing ADHD. Those
individuals whose behavior is most sensitive to reinforcer delay are making impulsive choices and therefore are more likely to meet diagnostic criteria for ADHD than those students whose behavior is not sensitive to reinforcer delay. In addition, this assessment may be useful in determining the effects of medication by conducting the assessment before and after medication is introduced to determine the effects on sensitivity to reinforcer delay. Initial studies using this methodology have found no difference between children who were and were not receiving medication (Neef, Markel et al. 2005) or on within subject performance on the reinforcer dimension assessment (Neef, Bicard, et al., 2005). However, neither of these studies assessed performance while titrating medication.

Since the original publication, the procedures of the reinforcer dimension assessment were made more efficient (Neef & Lutz, 2001) by using a computer to present the choices, mathematics problems, and record all of the data. In this study, 13 children ages 9 to 13 with emotional and behavioral problems participated in the study. Results indicated that reinforcer delay was the most influential dimension for 2 participants, quality for 1 participant, rate for 1 participant, and effort for 4 participants, while the remaining 3 participants’ responding was multiply influenced. These results further emphasized the individuality of sensitivity to various reinforcer and response dimensions.

One limitation of all of the studies discussed thus far is these studies identified relative influences of reinforcer dimensions on response allocation within an analogue situation; however, these data provide no information as to whether these results would
be successful at guiding interventions. This limitation was addressed in a second study by Neef and Lutz (2001 b). Two participants, ages 10 and 11 diagnosed with ADHD participated in the brief assessment procedures described above. The results indicated that for 1 participant, reinforcer delay was most influential followed by response effort, whereas for the second participant, reinforcer quality was most influential followed by response effort. In the second phase of the study, the authors used the results of the brief assessment to design an intervention that was implemented across multiple settings including the classroom, gym, lunchroom, and a public swimming pool. The interventions for both children targeted disruptive behavior such as negative statements, yelling, being out of seat, and talking during quiet time, all of which might be manifestations of impulsivity. The intervention consisted of differential reinforcement of low rate of behavior (DRL). A reversal design was used to assess the effects of manipulations in reinforcer delay (i.e., delivered at the end of the day or following a 24-hour delay) for the first participant and reinforcer quality (high-preferred versus low-preferred based on daily preference assessments) for the second participant. Results indicated that for both participants, the intervention that was based on the results of the brief assessment resulted in lower levels of disruptive behavior than the comparison intervention. This study provides a link from the assessment to treatment of impulsive behavior; however, there are several limitations. First, the data collection in the natural environment was discontinuous in that the experimenters reported data for the portions of the school day that they observed, whereas reinforcer delivery was based on the continuous data that the teachers collected. In addition, the interventions assessed were
layered on top of existing interventions raising questions as to whether the intervention alone or the intervention in combination with the existing treatment produced the change in behavior.

As with intervening activities, interventions based upon matching theory have been combined with a progressive delay to increase tolerance for delay. In a 2001 study, Neef, Bicard, and Endo assessed the impulsive behavior of 3 students, ages 9 to 11 diagnosed with ADD or ADHD. Following an initial baseline phase that tested for preference for high reinforcer quality and rate, reinforcer immediacy, and low effort mathematics problems, these reinforcer dimensions were placed in competition with each other using procedures similar to those described above. Next, those dimensions found to be most influential were placed in direct competition with reinforcer delay (e.g., low-quality reinforcer now versus high-quality reinforcer later). In addition, a progressive delay was introduced, systematically increasing the delay to the high-quality reinforcer until it reached delays of up to 24 hours. Finally, preference for delay versus other dimensions not used in the self-control training condition was reassessed. Results indicated that during baseline, delay was the most influential for all participants. Quality was second most influential for 2 participants and for the third, rate was the second most influential dimension. In the self-control assessment, when the second most influential dimension was placed in competition with delay, each participant’s response allocation switched to the delayed option and remained there throughout delay fading. In addition, self-control persisted during the post assessment when other dimensions that were previously shown to be less influential than delay were reassessed.
This study provides one of the first examples of response generalization in that self-control established during training with one reinforcer dimension maintained when other reinforcer dimensions were assessed. This is an important finding in that often it is not possible to manipulate a relevant reinforcer or response dimension (e.g., response effort) in the natural environment. However, these results suggest that after training with the most preferred dimension, manipulating a different dimension may be sufficient to maintain self-control.

In a similar study, Gwinn et al. (2005) increased the self-control of a 7-year-old male diagnosed with ADHD who engaged in severe problem behavior to escape task completion. After assessing the influence of reinforcer quality and response effort on response allocation and rate of severe problem behavior, a progressive delay was used within a concurrent choice paradigm to increase self-control. The delay to the later reinforcer was increased from zero seconds to 54 s. Results indicated that when the delay was brief, allocation remained towards the later reinforcer delivery and problem behavior remained low. However, as the delay was faded, response allocation became more variable and problem behavior increased. These results illustrate that although impulsive behavior may be addressed by manipulations in response allocation, other responses such as severe problem behavior may occur during delay fading. However, the authors did not attempt to recapture control over responding by shortening the delay as choice became more variable and problem behavior increased. Providing greater exposure to each delay length as well as making smaller increases in the delay may have increased the success to the intervention.
In summary, the above studies illustrate that competing reinforcer dimensions can be used successfully to address impulsive behavior within an analogue situation. In addition, the procedures used to assess the relative influence of reinforcer and response dimensions on response allocation have been made reasonably efficient in that an assessment can be conducted over the course of a few days. Finally, there is preliminary evidence that the results of these assessments can be used to guide interventions for classroom and other settings.

Several areas of research are still needed within this area. First and most importantly, further evidence is needed regarding the generalization of improvements in impulsive behavior beyond analogue conditions. Preliminary evidence suggests that this will occur (Neef, Bicard, & Endo, 2001; Neef & Lutz 2001b). In addition, although the delays assessed in many of these studies are longer than those from previous areas of research such as intervening activities, little information is known about extended delays. Finally, whereas Neef and Lutz (2001; 2001b) designed a more brief assessment for measuring impulsive behavior, there is still need for further procedural refinements. For instance, in many cases, behavior analysts or teachers do not have the luxury of conducting assessments over the course of multiple days; therefore, assessments that include delays of 24 hours between sessions make these procedures unfeasible. One potential approach to this issue is to examine the efficacy of the assessment using shorter delays; however, this will decrease the sensitivity of the assessment at measuring the impulsive behavior of individuals who can tolerate relatively short delays. A second approach is to examine the efficacy of the assessment when delay intervals are not
completed prior to the next session. This would enable the entire assessment to be completed relatively quickly and then delayed reinforcers can be provided as needed. Within this arrangement though, interaction effects may occur between earned but not obtained reinforcers and subsequent trials. In its support, Lagorio and Madden (2005) used a similar procedure in a delay-discounting task completed by adults without any apparent problems.

**Bundled Reinforcement and Commitment Strategies.** Reinforcement bundling and commitment strategies use similar principles but apply them differently. These techniques are based on the premise that when both alternatives are delayed at the time of choice, there is an increased probability that self-control will be demonstrated, that is the larger-later reinforcer will be chosen. Commitment strategies involve a single choice for a single reinforcer delivery; however, at the time of the choice, both the immediate and delayed outcomes are temporally distal. For example, at the start of the school day, a student could be asked to choose between a small reinforcer at the end of the day or a large reinforcer delivered the following morning. In contrast, reinforcement bundling consists of linking multiple reinforcer deliveries to a single choice response. In other words, one choice between smaller-sooner and larger-later reinforcers determines which reinforcer will be delivered for multiple reinforcer deliveries. Impulsive behavior for the delivery of the first reinforcer is likely because time of delivery is close to point of choice. However, at that point in time, all of the other deliveries are temporally distal, increasing the likelihood of self-control. As such, if
these deliveries are linked, the likelihood of impulsive behavior for the first delivery is offset by the likelihood of self-control on all subsequent deliveries.

Several basic studies have examined the effects of a commitment response on impulsive behavior. In a study by Rachlin and Green (1972), pigeons were provided a choice between a small amount of food immediately and a larger amount of food delayed by 4 s. Within this arrangement, response allocation was towards the key associated with the small amount of food delivered immediately. However, when an option to commit to the larger-later reinforcer and avoid the usual choice was provided, response allocation shifted as a function of the extent of the delay. That is, when the delay from the point of the commitment to the point of choice was short, allocation remained towards the smaller-sooner reinforcer, whereas when the commitment response was temporally distal from the point of choice, the pigeons’ allocation switched, favoring commitment to the larger-later reinforcer.

Ainslie (1974) used a single-subject design to explore the effects of a commitment response on the self-control of 10 pigeons within a delay-of-gratification paradigm. At the start of each 19 s trial, the single key in the chamber was illuminated green for 7.5 s. Pecks on the key while it was illuminated green constituted the commitment response and resulted in access to grain for the final 4 s of the trial. If the pigeon did not peck the green key, the key was darkened for 4.5 s. The key was then illuminated red for the next 3 s during which pecks resulted in immediate access to 2 s of grain. If no pecks occurred while the key was red access to grain was provided during the final 4 s of the trial. Several control conditions were used including (a)
extinction of the commitment response, (b) responses on the red key darkened the key but had no effect on the reinforcer delivery, and (c) the key only illuminated red following a response while the key was green. When the commitment response was available, 3 of the 10 pigeons consistently committed to the larger-later reinforcer. However, when the commitment response was placed on extinction during the control condition, responses on the key stopped. Results indicated that when the commitment response was not available, once the key was illuminated red, all pigeons responded on almost every trial resulting in the smaller-sooner reinforcer. Although these results are mixed, taken together with Rachlin and Green (1972) they suggest that commitment responses can be used to increase self-control in both temporal discounting and delay-of-gratification paradigms.

Several basic researchers also have examined the effects of reinforcer bundling on impulsive behavior. In a 2003 study with rats as subjects, Ainslie and Monterosso examined the effect of bundling reinforcement on impulsive behavior across various reinforcer amounts. Rats could respond on either of two levers, the left lever produced immediate access to sucrose solution ranging from 25 to 150 micro liters, the right lever produced access to 150 micro liters of sucrose solution. An inter-trial interval was used to hold all trials at an equal length regardless of the alternative chosen. Two conditions were compared, standalone and bundled. The only difference between the conditions was that in the bundled condition, responses on the left lever produced 1 reinforcer delivery, whereas responses on the right lever produced 3 reinforcer deliveries (e.g., at 3 s, 9 s, and 15 s). Results indicated preference for bundled reinforcement was
significantly higher than standalone reinforcement when the immediate reinforcer amount was small, but responding became more variable as the amounts became more similar.

In a similar study, Mitchell and Rosenthal (2003) further examined the effects of bundled reinforcement. In addition to examining multiple magnitudes for the immediate reinforcer, they also manipulated the delay to the larger reinforcer using values ranging from zero to 16 s using an adjusting delay procedure. During the bundling condition, two reinforcers were linked to one choice. Results indicated a statistically significant difference between single reinforcement and bundled reinforcement in every condition except when the delay was 16 s. The authors suggest that bundling delayed reinforcers increases the subjective value of that option and even after discounting its value is still greater than that of the immediate option. In addition, the authors suggest that each delayed reinforcer is discounted individually based upon the delay from the choice to the time of its receipt.

Several studies by Kirby and colleagues have examined the role of bundled reinforcement in human choice. In each of these studies, undergraduate college students completed a delay-discounting task using hypothetical rewards. Kirby and Guastello (2001) compared three conditions, imposed linking, free linking, and suggested linking. During the imposed linking condition, the experimenter directly bundled reinforcers, in the free linking condition, the participant could choose whether to bundle the reinforcers, whereas in the suggested linking condition, the experimenter suggested that present choices predict later ones. Results indicated that participants demonstrated the
least impulsive behavior in the imposed linking condition, followed by the suggested linking. The most impulsive behavior occurred during the free linking condition. A follow-up experiment ensured that the sequence of exposure to the conditions did not account for these results. During this experiment, the imposed linking condition was completed after the participants completed the free linking condition. Results indicated that no participants showed a linking effect in the free linking condition; that is all participants engaged in impulsive responding until the experimenters imposed the linking of reinforcers.

In a 2006 study, Kirby examined various parameters of bundled reinforcement including the overall value of the bundle, the value of the individual constituents of the bundle, and the effects of various arrangements of the delays within the bundle. During these experiments, the bundled condition consisted of 3 reinforcer deliveries and the delays assessed ranged from 1 to 46 days. As with that of Mitchell and Rosenthal (2003), results suggest that the present value of the bundled rewards is equal to the summation of the values of its constituents. However, unlike Mitchell and Rosenthal, these data suggest that variations in the delays between the constituents of the bundle do not have an effect on the overall value of the bundle. Finally, these results did not indicate a preference for uniform distribution of the delays within the bundle.

A study by Ragotzy, Blakely, and Poling (1998) illustrated the effects of increasing the delay to both alternatives, which is the basis of the commitment response. Three adults with severe mental retardation completed a fixed adjustment temporal discounting task. In the first phase of the experiment, the delay to the larger-later
reinforcer was increased by 5 s increments until consistent impulsive responding was observed. In the second phase, the delay to both alternatives was progressively increased while holding the difference between the alternatives constant. In other words, the delay to both the smaller-sooner and larger-later alternatives was increased by 5 s increments. Results indicated that as the delay to both alternatives increased, the likelihood of impulsive behavior decreased.

Unlike reinforcer bundling, commitment strategies have been applied within the context of a classroom. In an unpublished dissertation, Ferreri (2005) used a multiple baseline design to assess the effectiveness of a commitment response on the impulsive choice of 3 elementary school students. At the start of each work period, the students were asked to rank ten items from most to least preferred. Following the seatwork, the student exchanged his earned points for a prize, with low-preference items being available immediately, and high-preference items being available at the end of the day. The commitment response condition differed in that the students were asked to choose between the two reinforcer alternatives prior to completing the seatwork. Thus, a delay interval was introduced between the point of choice and both alternatives. During the commitment response condition, self-control increased for all participants, with the commitment to the larger-later reinforcer being made at nearly every opportunity.

Collectively, these results suggest that reinforcer bundling and commitment responses may be viable strategies for decreasing impulsive behavior within the classroom. However, to date there is limited research to support its present application. All human studies examining bundled reinforcement were purely basic research; that is
the task was arbitrary and the outcome of the study had no implications for the participants. Studies that incorporate reinforcer bundling into relevant classroom tasks and situations are needed prior to recommendations for implementation as a standalone technology. The results of Ferreri (2005) demonstrate a successful application of commitment response to the classroom environment. However, further research is needed as even within that study the condition was in place for a relatively short duration (e.g., 6 sessions at most).

**Self-control with Aversive Events.** Although impulsivity is often considered to be related mainly to choices involving concurrently available reinforcers (Ainslie, 1975), impulsive behavior also occurs in choices between two or more aversive events. With respect to aversive events, impulsive behavior is choosing to complete a larger delayed task over a smaller immediate task. For example, when presented with a choice between studying for small amounts across the course of the week or waiting until the night before the exam and studying for a long time, an impulsive choice would be to wait until the night before the exam to study. In scenarios such as this example, choosing to complete larger delayed tasks over smaller more immediate tasks is often referred to as procrastination. Unlike literature on impulsive behavior with reinforcing events, which has been studied extensively, there are a limited number of studies examining impulsive behavior with aversive events.

A 1978 study by Deluty included a series of experiments that explored the effects of various parameters of contingent electric shock on rats’ lever pressing within a concurrent operant arrangement. Depending upon which lever the rat pressed, one of
two shock arrangements occurred that differed in delay to shock presentation, duration of shock, or both. Results indicated that when shock duration was held constant, and delay to shock was varied across response alternatives, rats preferred delayed over immediate shock. In addition, when delay was held constant, increases in the duration of the shock as a consequence for one response alternative resulted in increases in responding on the other lever. That is, the rats demonstrated a preference for shorter shock durations. In the final two experiments, shock duration and delay were placed in competition. For example, responses on one lever produced a brief shock following a short delay, whereas responses on the other lever produced a longer shock following a longer delay. Within this arrangement, responses on the first lever indicate self-control, whereas responses on the second indicate impulsive choice. Results indicated that when the delay to both the immediate and delayed shocks was increased, responding switched from impulsive behavior (larger-later shock) to self-control (smaller-sooner shock). In addition, increasing the duration of the delayed shock also resulted in a reversal from impulsive responding to self-control.

In a follow up study, Deluty et al. (1983) further explored self-control with respect to aversive events. Rats’ engagement in a commitment response for a smaller-sooner shock was assessed within a reversal design. Across all conditions, the commitment response resulted in immediate removal of the response lever, a 5 s delay, and then a brief shock. If the commitment response did not occur within 5 s, the lever was removed for a delay to choice interval that varied across conditions. Following this delay to choice interval, the lever was represented for 5 s. Responses on the lever
produced an immediate brief shock whereas no lever press resulted in a long shock following a 5 s delay. Results indicated that as the delay to choice interval increased, commitment responses increased. In addition, when contingencies were reversed and the commitment “response” was not pressing the lever, commitment “responses” remained at high levels. Finally, when the commitment response was placed on extinction, that is, the choice between the smaller-sooner and larger-later shock was presented irrespective of lever presses in the initial link, commitment responses decreased. Collectively, these results indicate that rats will commit to the lesser of two aversive events when a commitment response is available. In addition, the probability of commitment responses increases as the interval between the commitment response and the point of choice increases.

The studies described above examined impulsive choices when shock was involved; however, several nonhuman studies have explored impulsive behavior in respect to task completion. Mazur (1996) examined the effects of various task parameters on pigeons’ choice between two tasks that interrupted a variable time (VT) schedule of food delivery. During these sessions, at some point in time, the VT schedule paused and a ratio schedule had to be completed in order to resume the VT schedule. Indifference points were measured using a concurrent schedules paradigm. Choices between a fixed ratio (FR) 5 that interrupted the VT schedule relatively early versus an adjusting ratio schedule that interrupted the VT schedule at a relatively later point in time were presented. Results indicated that pigeons reliably engaged in impulsive behavior with respect to task completion. That is, they chose a larger delayed
task over a more immediate smaller task. In addition, as the time to the onset of the larger delayed work period increased, the likelihood of choosing the larger-later increased. These results were replicated when the same arrangement was conducted in the absence of the variable time food delivery. Mazur (1998) replicated these findings using fixed interval (FI) schedules instead of FR schedules. Results once again indicated that pigeons would engage in impulsive choices. However, as the delay to the sooner FI schedule increased, preference for that schedule increased. Collectively, these results suggest that various arrangements of work also function as aversive events, and as with shock, manipulating the delay and size of the aversive event promotes self-control.

One of the earliest studies to examine impulsive choice for aversive events in humans was conducted by Grusec (1968) using a group design. Children were asked to make 16 choices between smaller aversive events that would occur immediately or larger aversive events that would occur following a 2-week delay. The children were instructed that one of their choices would be randomly selected and they would have to complete the event that they chose. Events assessed included eating unpleasant food, memorizing lines of boring poetry, spending time with an unpleasant teacher, and completing difficult tasks in front of the class. Results indicated that when magnitude was held equal across response alternatives, the children chose the larger more delayed aversive event approximately 50% of trials. However, as the magnitude of the delayed event increased, there was an increased likelihood that self-control would be exhibited and the smaller more immediate aversive event would be chosen.
One of the few applied studies that examined self-control with respect to aversive events was conducted by Lerman et al. (2006). In this study, two task dimensions, task magnitude (e.g., the number of discrete trials required) and delay to task were manipulated to increase self-control. Two 4-year-olds, who were diagnosed with autism and engaged in escape maintained problem behavior, participated in the study. Using a concurrent schedules arrangement, preference for low over high magnitude tasks and for delayed over immediate tasks was assessed. These preferences indicated that the tasks functioned as aversive events and choice allocation was impulsive. During a self-control assessment, the effects of placing task magnitude and delay to task completion in direct competition were assessed via a reversal design. In the initial condition, low-magnitude tasks were paired with immediate completion, whereas high-magnitude tasks were paired with delayed completion. Next, manipulations in task parameters were made such as increasing the extent of the delay to both the immediate and delayed task, increasing the magnitude of the delayed task, and decreasing the magnitude of the immediate task. Results indicated that both participants allocated their responding towards the smaller magnitude tasks and the delayed tasks during the initial assessments. In the self-control assessment, one participant demonstrated self-control when provided a choice between small immediate tasks and delayed large tasks. Self-control maintained when increases in the task magnitude for both alternatives were made and when the delay to both the immediate and delayed tasks was increased. For the second participant, increases in the delay to both
immediate and delayed tasks had minimal effect and changes in task magnitude had no effect on his response allocation.

This study suggests that manipulations in various task parameters may be a viable option for increasing self-control in respect to aversive events. However, there are several limitations with this study. First, there were only 2 participants, only one of whom had positive results in respect to increasing self-control. Second, there were differential delays to negative reinforcement across response alternatives. That is, choosing an immediate or smaller task resulted in more immediate access to negative reinforcement than choosing a delayed or larger task. However, had trial length been held constant, the extent of the negative reinforcement would have been inconsistent and choosing smaller or immediate tasks would result in a longer wait until the start of the next trial than choosing the delayed or larger task. In addition, because the participants were prompted to complete the task, choices associated with larger task magnitude resulted in more attention in the form of prompts than choices associated with smaller task magnitude.

Collectively, the results of these studies suggest that procrastination, or impulsive choice with respect to aversive events, is consistent with that of impulsive choice regarding reinforcers. That is, as the interval between the choice response and the event increases, that event has less effect on choice. In the case of aversive events, longer delays make impulsive behavior less probable, whereas in the case of reinforcers, longer delays increase the probability of impulsive behavior. In addition, it appears that as with impulsive behavior involving reinforcers, manipulations in parameters such as
magnitude and delay to the event may promote self-control. However, there are a limited number of studies involving both nonhumans and humans. In addition, only one study (Lerman et al., 2006) actively sought to change behavior in a socially significant manner and this was met with limited success. Future studies should further examine the effects of various task parameters on procrastination with socially significant behaviors. In addition, whereas the above studies manipulated the magnitude of the aversive event (e.g., duration of shock, Deluty, 1978; Deluty et al., 1983; or response frequency, Mazur, 1996; Mazur, 1998, Lerman et al.) future research should examine the role of task difficulty. That is, classroom situation often involve choices between tasks that are easier (completing mathematics problems with a calculator) and those that are more difficult (completing mathematics problems without a calculator), it would be useful to develop a technology to promote choice of the more difficult tasks.

Summary

Assessment. With respect to concerns regarding the types of rewards used in discounting tasks, the literature suggests that when participants are typically developing adults, there is no difference between purely hypothetical rewards and procedures that deliver one randomly selected real reward. In addition, these studies suggest that the incorporation of forced choice trials as well as steady state responding do not appear to be necessary. Recent literature also has examined the utility of objective measures of impulsivity as a diagnostic tool. Results of these preliminary studies suggest that these tasks hold promise as a diagnostic tool for diagnoses, which include impulsivity as a defining feature (e.g., ADHD and some psychiatric disorders).
Treatment. This review discussed four methods for treating impulsive behavior, (a) progressive delay, (b) intervening activities, (c) competing reinforcer dimensions, as well as (d) commitment responses and bundled reinforcement. The research suggests that each of these methods is effective in increasing self-control, but there are varying amounts of support for applied use. For instance, application of intervening activities and competing reinforcer dimensions received the most attention in applied settings. These interventions were used to decrease the impulsive behavior of both children and adults with a variety of diagnoses. In addition, they were applied in a variety of settings (e.g., schools, residential facilities, and the community) and situations (e.g., completion of academic tasks, vocational tasks, and physical therapy). Furthermore, intervening activities were successfully applied within the context of a group activity.

There is considerably less support for the applied use of commitment strategies and bundled reinforcement. Although the effects of bundling reinforcers on impulsive behavior have been studied with humans in the laboratory, this author was unable to identify an application of this methodology in an applied setting. Similarly, the literature on commitment responses has predominantly been basic in nature with only an unpublished dissertation demonstrating its utility in applied settings.

Support for the applied use of progressive delay as a standalone technology is limited, mainly because it frequently is combined with other interventions (e.g., intervening activities and competing reinforcer dimensions). However, it seems parsimonious to compare this procedure with other fading procedures that have
successfully increased task compliance (Pace, Ivancic, & Jefferson, 1994; Piazza, Moes, & Fisher, 1996) and bite acceptance (Najdowski, Wallace, Doney, & Ghezzi, 2003) as well as removed mechanical restraints (Lerman, Iwata, Smith, & Vollmer, 1994; Pace, Iwata, Edwards, & McCosh, 1986). One possible explanation for the success of these procedures is that gradual increases in response requirements, as in progressive delay and demand fading, increase the likelihood of contacting reinforcement; thus strengthening responding.

The treatment of impulsive behavior with respect to aversive events has received little attention in both basic and applied literature. The research that has been completed encompasses both presentation of aversive stimuli (e.g., shock and unpleasant tasting food) and aversive tasks (e.g., FR schedules that interrupt reinforced delivery and academic tasks). Across both types of aversive events, manipulations in various parameters of those events have decreased impulsivity in both nonhumans and humans.

**Directions for Future Research**

**Assessment.** Several important questions regarding the assessment of impulsive behavior remain unanswered. With respect to the methodological concerns, the effects of hypothetical rewards as well as the exclusion of forced exposure trials and steady state responding requires examination in populations other than typically developing adults. As indicated by Grosch and Neuringer (1981), behavioral history affects impulsive responding. Therefore, those individuals who have limited histories (e.g., children, individuals with developmental disabilities, and acquired brain injuries) may perform differently when real rewards are substituted with hypothetical ones and a
history is not established via forced choice trials. Future research should replicate existing studies using different populations.

The literature discussing objective measures of impulsivity also leaves a number of unanswered questions. First, more studies need to be conducted demonstrating the differences in performance of individuals who are at risk for being impulsive and those who are not. Second, questions remain as to whether performance on a task that objectively measures impulsivity correlates with impulsive behavior in natural settings. Finally, research comparing real and hypothetical rewards should be used to inform these assessments. For example, an assessment that uses all hypothetical rewards is the most efficient but needs further research to support its use across populations.

**Treatment.** Several important areas for future research remain across treatment methodologies. One limitation of most of the reviewed studies was the extent of the delay measured during the intervention phase. In many cases, these delays were only a few minutes or less. In order for an intervention to be successful in an applied setting, it is likely that individuals will need to tolerate delays much longer than these. As such, future research should incorporate delays that more closely approximate those in the natural setting. A second limitation was the absence of data showing the generalizability of the interventions. For example, with the exception of Neef and Lutz (2001b) and Ferreri (2005) none of the studies demonstrated that self-control occurred outside of an analogue setting. Future research should further demonstrate the effectiveness of these interventions in natural environments.
Although intervening activities have received relatively high amounts of attention, the scope of the research has been rather narrow. For example, research suggests that in many cases the form of the intervening activity is not important, but little is known about the functional aspects of these activities. Intervening activities may function as a distraction from the delay or as a stimulus that increases attending towards the future reinforcer. Understanding the function of intervening activities and individual preferences for one function over the other would direct selection of activities and likely increase treatment success. A second question that remains with respect to intervening activities is whether engagement in the activity should be required or simply free access to the activity is sufficient. Finally, if free access to the activity is sufficient, is there a minimum amount of engagement that is necessary to ensure self-control will be demonstrated. Again, understanding the functional aspects of these activities may help to answer some of these questions.

Bundled reinforcement and commitment strategies as interventions for socially significant behavior are in an infant stage at best. Nonhuman studies have demonstrated the efficacy of linking multiple reinforces together in order to promote self-control and laboratory studies have shown adults will allocate more responses towards delayed reinforcers when reinforcers are linked in some way. However, before this technology can be recommended for widespread adoption, demonstration of its utility at decreasing impulsive responding in settings such as the classroom is required. Similarly, commitment strategies have little support for applied use. The Ferreri (2005) study provides preliminary evidence but further investigation is needed.
As discussed above, treatment of impulsive behavior with aversive events has received little attention in the applied literature. Lerman et al. (2006) provide a preliminary investigation into the effectiveness of manipulations in task parameters to increase self-control. However, this study only assessed the influences of task delay and magnitude and only 2 children participated in the study. Further research is needed as to the effects of manipulations of these parameters as well as others (e.g., task difficulty) on self-control with aversive events. Although the Lerman et al. study translated basic research to an applied problem, the next step that brings the technology to truly applied situations is necessary. For example, after demonstrating self-control with aversive events in an analogue setting, generalization to the classroom or workplace needs to be demonstrated.

**Recommendations for Practice**

The conclusions of this review suggest several practices for special education providers. When designing interventions to increase self-control, a reinforcer dimension assessment should be conducted to identify those dimensions that are most influential on an individual’s behavior. Influential reinforcer and response dimensions should be placed in competition with reinforcer delay during treatment. Whenever possible, intervening activities should be provided during delays. Although low-preference activities may increase self-control, high-preference activities should be used when possible. Finally, use of a progressive delay procedure may be beneficial in shaping a repertoire of self-control.
Chapter 3

Study I: Task Parameter Manipulation

Method

Participants and Setting

Children who attended an urban private school for individuals with autism were invited to participate by a recruitment letter (see Appendix A). As a requisite for participation, all children met the following requirements: (a) they had basic computer skills (e.g., use of keyboard to enter responses and mouse to click on buttons on the screen), (b) they had basic arithmetic skills (e.g., single-digit addition or subtraction), (c) they were identified by their teachers/and or parents as needing improvement with arithmetic, and (d) their parents or guardian consented to the child’s participation in the study (see Appendix B). Two boys and two girls, diagnosed with autism, were referred for participation. At the time of the study, Krista was 10-years-old while Pru, Dante, and Nate were 8-years-old. All of the children were Caucasian. All of the children had a history of non-compliance and/or problem behavior associated with task completion. At the time of the study, Krista and Nate had individualized behavior support plans to
address their problem behaviors, whereas classroom management plans were used to support Dante and Pru.

The study took place at Helping Hands Center for Special Needs, a privately operated center that provided early intervention and educational services for children 3 to 12-years-old. At the time of the study, the center served 76 children, 10 of whom were typically developing peers. Approximately 82% of the children were Caucasian, 11% were African American, 6% were Asian, and 1% were Hispanic.

All sessions were conducted in a small room located adjacent to the supervisors’ office. The entrance to this room was unobstructed providing a clear view of the office. The room contained a table, chairs, a computer, and a storage cabinet. Sessions were conducted 3 to 4 days per week at different times throughout the day to accommodate the participants’ schedules.

**Apparatus and Data Collection**

All experimental tasks were completed using either a laptop or desktop computer equipped with a keyboard, an external mouse, and a software program designed for the study. The program provided a menu by which the experimenter selected the parameters for two sets of mathematics problems. The parameters included the delay to the presentation of each task, the magnitude of each task (e.g., number of mathematics problems), and the difficulty of each task (e.g., single-digit sums to 19). Participants selected tasks by using the mouse to place a pointer over a button on the screen and then click the mouse button. All responses to mathematics problems were entered using the
number keys on the keyboard followed by pressing the “Enter” key or using the mouse to click the “Check” button on the screen.

All data were collected by the computer program. Frequency data were collected for choice of each task. Choice of a task was defined as placing the mouse pointed over the button on the computer screen assigned to that task, and depressing the left mouse button such that the computer registers the button press. In addition, the mathematics problems presented and participant answers to the problems were recorded. Procedural fidelity data were collected by an independent observer for at least 25% of sessions for all participants (see Table 3.1). Data were collected as to whether the experimenter entered the session parameters as per the session log, provided the participant with attention during the session, and correctly recorded the output data totals on the session log. Levels of procedural integrity were 100% for all participants.

Table 3.1. Procedural fidelity data for study 1.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Sessions</th>
<th>Percentage of Sessions</th>
<th>Average Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dante</td>
<td>14</td>
<td>27.45</td>
<td>100</td>
</tr>
<tr>
<td>Pru</td>
<td>8</td>
<td>25.00</td>
<td>100</td>
</tr>
<tr>
<td>Krista</td>
<td>10</td>
<td>25.64</td>
<td>100</td>
</tr>
<tr>
<td>Nate</td>
<td>12</td>
<td>26.67</td>
<td>100</td>
</tr>
</tbody>
</table>
General Procedures

The purpose of study 1 was to examine the effects of manipulations in various task parameters on self-control. Task delay, magnitude, and difficulty were manipulated using a concurrent schedules design within a reversal design. Procedures used were similar to those described by Lerman, Addison, and Kodak (2006). Prior to the self-control assessment, each child participated in a pre-assessment consisting of a mathematics skills assessment, a task avoidance assessment, and a task parameter assessment.

Except for the mathematics skills assessment, all sessions consisted of 2 forced-choice trials followed by 5 free-choice trials. Each trial consisted of one choice between the available alternatives and the consequence programmed for that choice (i.e., a task or a break). Forced-choice trials were conducted to expose the participant to the task parameters arranged for each alternative. During forced-choice trials, the experimenter pointed to an alternative and told the child to “choose this side.” The order of the alternatives during the forced choice trials was randomized across sessions. Free-choice trials began immediately following the completion of the second forced-choice trial. Both forced-choice and free-choice trials began with the choice screen (see below), which displayed two alternatives. Each alternative had a label (e.g., smaller-sooner) and a selection button. Clicking on the button associated with one alternative resulted in the presentation of the chosen task (see Figure 3.1). Correct responses resulted in feedback in the form of “Correct” whereas incorrect responses resulted in feedback in the form of “Incorrect, Try Again.” Following two incorrect attempts at a problem, the correct
answer was displayed on the screen, after which the program presented the next event in the trial.

Figure 3.1. Computer screen during the choice presentation (left) and mathematics problem presentation (right).

Pre-assessment Procedures

The pre-assessment consisted of three parts; (a) a mathematics skills assessment, (b) a task avoidance assessment, and (c) a task parameter assessment.

Mathematics skills assessment. The mathematics skills assessment was conducted to (a) confirm that the participant could complete basic mathematics problems, (b) identify the problem difficulty level to be used in subsequent conditions, and (c) familiarize the children with the computer program. Each 3 minute session consisted of a single level of mathematics problems (e.g., single-digit addition sums to 19). One problem was presented at a time and the participant used the keyboard and
mouse to enter his/her response. Sessions were conducted until the participant completed less than 75% of the problems attempted correctly. If more than one level of mathematics problems was identified for use, the level of mathematics problems in which the participant completed (a) the most problems correctly was chosen for the low-difficulty level, (b) a moderate number of problems correctly was chosen for the medium-difficulty level, and (c) the least problems correctly was chosen for the high-difficulty level. Table 3.1 depicts the results of each child’s mathematics skills assessment.

Table 3.2. Difficulty levels assessed and selected during the mathematics skills assessment.

<table>
<thead>
<tr>
<th>Name</th>
<th>Problem 1</th>
<th>% Correct</th>
<th>Problem 2</th>
<th>% Correct</th>
<th>Problem 3</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dante</td>
<td>Single-digit sums to 19</td>
<td>81\textsuperscript{d}</td>
<td>Two-digit sums to 24</td>
<td>33</td>
<td>Single-digit subtraction</td>
<td>0</td>
</tr>
<tr>
<td>Pru</td>
<td>Single-digit sum to 19 (manipulatives)</td>
<td>78\textsuperscript{c}</td>
<td>Single-digit sums to 9 (manipulatives)</td>
<td>100\textsuperscript{a}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krista</td>
<td>Single-digit sums to 19 (manipulatives)</td>
<td>100\textsuperscript{c}</td>
<td>Single-digit sums to 9 (manipulatives)</td>
<td>100\textsuperscript{a}</td>
<td>Single-digit subtraction (manipulatives)</td>
<td>100\textsuperscript{b}</td>
</tr>
<tr>
<td>Nate</td>
<td>Single-digit sums to 19</td>
<td>92\textsuperscript{d}</td>
<td>Two-digit sums to 24</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a}. Problem type used as low difficulty  
\textsuperscript{b}. Problem type used as medium difficulty  
\textsuperscript{c}. Problem type used as high difficulty  
\textsuperscript{d}. Problem type used for all assessments
Task avoidance assessment. The purpose of the task avoidance assessment was to determine whether, if given a choice, the participant would choose to avoid completing mathematics problems. During each trial, the participant was given a choice between completing mathematics problem and taking a break. The button associated with the break was labeled “Break” and the button associated with the mathematics task was labeled “Work.” Clicking the break button resulted in the avoidance of the presentation of mathematics problems for that trial and a blank screen for the remainder of the trial (e.g., 60 s). Clicking on the work button resulted in the presentation of a medium magnitude of high-difficulty mathematics problems (e.g., 10 single-digit addition problems sums to 19). After the task was completed, the next trial began immediately.

Task parameter assessment. The task parameter assessment was conducted to determine the participants’ sensitivity to high and low values of each task parameter (difficulty, delay, magnitude). In each phase, high and low values of one parameter were presented while all other parameters were held constant across the alternatives. During the magnitude baseline, participants chose between completing a small amount (i.e., 1) of medium-difficulty mathematics problems and a large amount (i.e., 10) of medium-difficulty mathematics problems. During the difficulty baseline, participants chose between completing a medium amount (i.e., 5) of low-difficulty mathematics problems and a medium amount of high-difficulty mathematics problems. The high and low levels of mathematics problems presented during the difficulty baseline were determined by performance during the mathematics skills assessment. During the delay
baseline, participants chose between completing a medium amount of mathematics problems immediately and a medium amount of mathematics problems following a delay (i.e., 60 s). If the participant chose the immediate task, after completing the task, the next trial began after a delay equal to that of the delayed alternative (i.e., 60 s). If the participant chose the delayed task, the next trial began immediately after completion of the mathematics task.

**Self-control Assessment Procedures**

The purpose of the self-control assessment was to determine whether manipulations in the task parameters affected each participant’s self-control (i.e., choice of the more immediate task). Figure 3.2 diagrams the procedures for a basic trial from the self-control assessment. Each participant’s self-control assessment differed due to individual response allocations.

![Diagram of self-control procedures](image-url)

Figure 3.2. Diagram of the self-control procedures where A is the value of the delay to both alternatives and D is the value of the delay to the later alternative.
**Dante.** Initially, Dante was given a choice between completing 1 mathematics problem now and 10 mathematics problems following a 60 s delay (see D in Figure 3.2). Next, the magnitude of the immediate task was increased from low to medium to determine whether variations in task magnitude would affect self-control. Finally, the effects of increasing the delay to both alternatives (see A in Figure 3.2) was assessed by systematically increasing the delay in 10 s increments.

**Pru.** The initial phase of Pru’s self-control assessment consisted of a choice between completing 5 low-difficulty mathematics problems immediately and 5 high-difficulty mathematics problems following a 60 s delay. Next, the delay to both alternatives was increased first by 10 s and then 30 s. Finally, the magnitude of the more immediate alternative was decreased to determine the effects of changes in task magnitude on self-control.

**Krista.** The initial phase of Krista’s self-control assessment was identical to that of Pru. Next, the difficulty level of the immediate task was increased from low to medium to determine whether increased task difficulty would affect self-control. Finally, the effects of changes in delay to task were assessed by increasing the delay to both alternatives by 10 s increments.

**Nate.** Nate’s self-control assessment was similar to Dante’s. Following an initial choice between completing 1 mathematics problem immediately and 10 mathematics problems after a 60 s delay, the magnitude of the immediate task was increased from small to medium. Next, the delay to both task alternatives was increased by 10 s increments to assess the effects of changes in the delay to both alternatives.
Chapter 4

Study I: Task Parameter Manipulation

Results & Discussion

Dante

Task avoidance assessment. Results of the task avoidance assessment for Dante are shown in the first phase of Figure 4.1. The percentage of trials during which Dante chose to avoid task completion averaged 50% (range, 40% to 60%). Although responding was variable, there was no trend during this phase. These results suggest that Dante had no preference between avoiding and completing tasks.

Task parameter assessment. The remaining phases of Figure 4.1 show the results of Dante’s task parameter assessment. In the magnitude baseline (phase 2), Dante could choose between completing a small task immediately and a large task immediately. Following a decreasing trend, levels of choice of the large task remained at zero for two sessions. Average level of choice of the large task was 26.67% (range, 0% to 60%). In the delay baseline, when Dante could choose between completing a medium task immediately or following a 60 s delay, responding was variable, but
overall allocation was towards the delayed alternative throughout the phase. Average level of choice of the immediate task was 16% (range, 0% to 40%). Collectively, these results suggest that Dante preferred tasks of smaller magnitude and preferred to delay task completion.

Figure 4.1. Percentage of trials in which Dante chose a break (phase 1) during the task avoidance assessment as well as a large task (phase 2) and immediate task (phase 3) during the task parameter assessment.

**Self-control assessment.** Results of the self-control assessment for Dante are shown in Figure 4.2. In the first phase, when Dante could choose between completing a
small task immediately or a large task following a 60 s delay, Dante allocated his choice
towards the smaller immediate task (M=55%; range, 0% to 80%). Because Dante
demonstrated self-control, the magnitude of the immediate alternative was increased
beginning in session 9. Following this change, choice of the smaller immediate task
decreased across the phase until zero levels were obtained for two sessions (M=24%;
range, 0% to 80%). Choice of the smaller-sooner alternative remained low when the
delay to both alternatives was increased by 10 s (M=6.67%; range, 0% to 20%).
However, a moderate increase in level occurred when a 20 s delay to both alternatives
was introduced (M=45%; range, 20% to 60%). When the delay to both alternatives was
30 s (beginning session 21), allocation switched and Dante chose the more immediate
alternative more often than the delayed alternative (M=70%; range, 60% to 80%).
Removal of the delay to both alternatives at session 25 resulted in a decrease to low
levels (M=25%; range, 0% to 60%). When the 30 s delay to both alternatives was
reintroduced beginning in session 29, allocation once again shifted with moderate to
high levels of choice of the more immediate alternative (M=65%; range, 60% to 80%).
Figure 4.2. Percentage of trials in which Dante chose the more immediate task during the self-control assessment. Numbers indicate the delay values (in seconds) and the task magnitude associated with each choice.

Pru

**Task avoidance assessment.** Results of the task avoidance assessment for Pru are shown in the first phase of Figure 4.3. Choice of task avoidance increased from moderate to high levels across the phase. On average, Pru allocated 85% of her choice towards task avoidance (range, 60% to 100%). These results suggest that task completion was an aversive event for Pru.
Figure 4.3. Percentage of trials in which Pru chose a break (phase 1) during the task avoidance assessment as well as a large task (phase 2), high difficulty task (phase 3), and immediate task (phase 4) during the task parameter assessment.

**Task parameter assessment.** The task parameter assessment for Pru started during session 5. During the magnitude baseline (phase 2), Pru selected the smaller task 100% of trials across three sessions. Beginning at session 8, the effects of task difficulty on response allocation was evaluated. Choice of the high difficulty task was low throughout the phase (M=6.66%; range, 0 to 20%). In the delay baseline when Pru could choose between completing a medium task (5 mathematics problems) immediately or following a 60 s delay, allocation was towards the delayed alternative.
throughout the phase. On average, Pru chose the immediate task 20% of trials (range, 0% to 40%). Collectively, these results suggest that Pru’s choice was sensitive to task magnitude, difficulty, and delay, preferring low values of magnitude and difficulty and high values for delay.

**Self-control assessment.** Figure 4.3 depicts the results of the self-control assessment for Pru. In the first phase, choice alternatives were completing a low-difficulty task immediately or a high-difficulty task following a 60 s delay. Pru did not demonstrate self-control, selecting the high difficulty delayed task 100% of trials for three consecutive sessions. Responding did not change when a 10 s (session 4) and 30 s (session 7) delay to both tasks was introduced. Beginning during session 10, the magnitude of the low-difficulty immediate task was decreased from medium to small. Choice of the more immediate alternative increased sharply and was 100% for the final two sessions of the phase (M=93.33%; range, 80% to 100%). During the reversal, when the size of the immediate alternative returned to a medium magnitude (beginning session 13), preference for the delayed alternative returned (M= 13.33%; range, 0% to 40%). High levels of choice of the more immediate alternative returned in phase 6 when the magnitude was again reduced to 1 mathematics problem (M= 92%; range, 60% to 100%).
Figure 4.4. Percentage of trials in which Pru chose the more immediate task during the self-control assessment. Phase labels indicate the delay values (in seconds), the task difficulty level, and the task magnitude associated with each choice.

Krista

**Task avoidance assessment.** Results of the task avoidance assessment for Krista are shown in the first phase of Figure 4.5. The percentage of trials during which Krista chose to avoid task completion averaged 90% (range, 80% to 100%). These results suggest that task completion was an aversive event for Krista.
Figure 4.5. Percentage of trials in which Krista chose a break (phase 1) during the task avoidance assessment, as well as a large task (phase 2), high difficulty task (phase 3), and immediate task (phase 4) during the task parameter assessment.

Task parameter assessment. The remaining phases of Figure 4.5 show the results of Krista’s task parameter assessment. In the magnitude baseline (phase 2), levels of choice of the larger task were initially low and then decreased to and remained at zero for three sessions. Average level of choice of the larger task was 5% (range, 0% to 20%). A similar pattern of responding was observed during the difficulty baseline. During session 9, Krista chose the high-difficulty task 40% of trials, after which choice of the high-difficulty task decreased to and remained at zero for three sessions. Average
level of choice of the high-difficulty task was 10% (range, 0% to 40%). In the delay baseline (phase 4), choice of the delayed task was low and stable (M=36.67%; range, 20% to 40%). Collectively, these results suggest that Krista preferred small tasks, tasks of low difficulty, and delayed tasks.

**Self-control assessment.** Results of the self-control assessment for Krista are shown in Figure 4.6. In the first phase, when Krista could choose between completing a low-difficulty task immediately or a high-difficulty task following a 60 s delay, Krista demonstrated self-control, allocating her choice towards the low-difficulty immediate task (M=95%; range, 80% to 100%). Following the increase in the magnitude of the immediate alternative (phase 2) choice of the immediate task decreased to moderate levels which were stable throughout the phase (M=51.43%; range, 40% to 60%). A 10 s delay to both alternatives was introduced during phase 3, after which an immediate increase in choice of the more immediate alternative was observed (M=90%; range, 80% to 100%). Removing the delay to both alternatives during phase 4 resulted in a return to low levels of choice of the immediate alternative. On average, choice of the immediate alternative was 60% (range, 40% to 100%). The 10 s delay to both alternatives was reintroduced during the final phase of this assessment. Choice of the more immediate alternative immediately returned to and remained at high levels throughout the phase (M=95%; range, 80% to 100%).
Figure 4.6. Percentage of trials in which Krista chose the more immediate task during the self-control assessment. Phase labels indicate the delay values (in seconds) and the task difficulty level with each choice.

Nate

Task avoidance assessment. Results of the task avoidance assessment for Nate are shown in the first phase of Figure 4.7. Levels of task avoidance were variable early in the phase after which high and stable levels were observed. The percentage of trials during which Nate chose to avoid task completion averaged 68% (range, 40% to 80%). These results suggest that for Nate, task completion was an aversive event.
Figure 4.7. Percentage of trials in which Nate chose a break (phase 1) during the task avoidance assessment, as well as a large task (phase 2) and immediate task (phase 4) during the task parameter assessment.

Task parameter assessment. The results of Nate’s task parameter assessment are shown in the remaining phases of Figure 4.7. In the magnitude baseline (phase 2), choice of the large task decreased from moderate levels and remained at zero for the final two sessions. Average level of choice of the large task was 15% (range, 0% to 40%). In the delay baseline (phase 3), when Nate could choose between completing a medium task immediately or following a 60 s delay, allocation favored the delayed alternative throughout the phase. Moderate levels of choice of the immediate alternative
were observed initially, after which allocation decreased and remained at zero for the final two sessions. Choice of the delayed task averaged 17.14% (range, 0% to 40%). Collectively, these results suggest that Nate preferred smaller magnitude tasks and delayed task completion.

![Percentage of trials in which Nate chose the more immediate task during the self-control assessment. Numbers indicate the delay values (in seconds) and the task magnitude associated with each choice.](image)

Figure 4.8. Percentage of trials in which Nate chose the more immediate task during the self-control assessment. Numbers indicate the delay values (in seconds) and the task magnitude associated with each choice.

**Self-control assessment.** Results of the self-control assessment for Nate are shown in Figure 4.8. In the first phase, when Nate could choose between completing a
small task immediately or a large task following a 60 s delay, Nate initially demonstrated high levels of variability in choice of the immediate alternative. Beginning with session 5, choice of the immediate alternative was at 100% and remained there for the final four sessions of the phase. Overall, the average choice of the immediate alternative was 72.5% (range, 0% to 100%). During phase 2, the magnitude of the immediate alternative was increased. Low and stable levels of choice of the immediate alternative were observed across the phase (M=15%; range, 0% to 20%). In phase 3, a 10 s delay to both alternatives was introduced. Choice of the more immediate alternative increased to high levels, although some variability was observed (M=62.86%; range, 20% to 80%). After the delay to both alternatives was removed (phase 4), levels of choice of the immediate alternative immediately decreased. Levels were stable across the phase and averaged 36% (range, 20% to 40%). When the delay to both alternatives was reintroduced during phase 5, high and stable levels of choice of the more immediate alternative were observed (M=72%; range, 60% to 80%).

**Discussion**

The purpose of study 1 was to examine the effects of manipulating task parameters on self-control. Task magnitude manipulations were conducted for Dante, Pru, and Nate. In each case, changes in the number of mathematics problems presented affected self-control. For instance, both Dante and Nate demonstrated self-control in the first phase of the self-control assessment. That is, they preferred a small immediate task to a larger delayed task. However, their preference switched from the immediate to the delayed alternative when the magnitude of the immediate alternative was increased.
indicating a decrease in self-control. Similar sensitivity to task magnitude was observed for Pru, who demonstrated increased self-control when the magnitude of the immediate task was reduced. Changes in task difficulty were conducted with Krista. Krista’s self-control was affected by changes in task difficulty. When presented with a choice between completing low difficulty problems immediately and high difficulty problems later, Krista demonstrated self-control. However, her self-control decreased when the mathematics problems for the immediate alternative were made more difficult. Changes in delay to task completion affected self-control for Dante, Krista, and Nate. That is, systematic increases in the delay to both alternatives resulted in increased preference for the immediate alternative. Increases in delay to both alternatives did not affect Pru’s self-control, however.

Overall, the results of this study indicated that each child’s self-control was sensitive to manipulations in at least one task parameter. These results are similar to those of previous research. For instance, changes in the duration of a shock (Deluty, 1978) and delays to both alternatives (Deluty, 1978; Mazur, 1996, 1998) have been shown to affect self-control in non-humans. Furthermore, Lerman et al. (2006) demonstrated that changes in task magnitude and delay resulted in increased self-control for one child with autism.

In addition to replicating findings of previous research, the findings of the present study add to the literature by demonstrating that changes in task difficulty can affect self-control. Similar to changes in task magnitude, changes in the difficulty level of the immediate alternative were inversely related to self-control. Variations in task
difficulty can be conceptualized as changes in response effort. That is, in the present study, mathematics problems that were more difficult, required increased effort to solve accurately. As such, it would be expected that tasks that are require more effort to complete would be more likely to produce avoidance responses than those requiring less effort.

One interesting finding was the sensitivity demonstrated by some participants to increases in the delay to both alternatives. Response allocation for both Nate and Krista switched following the introduction of a 10 s delay. One possible explanation for this is the varying degree to which this change is discriminable for each alternative. The introduction of a delay prior to immediate task completion is a relatively salient change, whereas the addition of time to the delay for the delayed alternative is likely to be more difficult to discriminate. Another explanation is the addition of a pre-task delay in the immediate alternative resulted in two inter-trial intervals with no work requirement, one before the task and one after. The delayed alternative, however, remained at just one work free inter-trial interval. Thus responding may have been controlled more by the number of work free periods than the task parameters.
Chapter 5

Study II: Commitment Response

Method

Participants and setting

Three children (Dante, Pru, & Nate) who participated in study 1 served as participants. As in study 1, all sessions were conducted in a small room off the supervisors’ office. Sessions were conducted 3 to 4 days per week at different times throughout the day to accommodate the participants’ schedules.

Apparatus and Data Collection

All experimental tasks were completed using either a laptop or desktop computer equipped with a keyboard, an external mouse, and a software program designed for the study. The program provided a menu by which the experimenter selected the parameters for two sets of mathematics problems. In addition, the experimenter could assign the availability of a commitment response and the duration of the commit delay.

All data were collected by the computer program in the same manner as in study 1. In addition, frequency data were collected for commitment responses. Commitment
responses were defined as placing the mouse pointer over the commit button on the computer screen and depressing the left mouse button such that the computer registered the button press. Procedural fidelity data were collected by an independent observer for at least 25% of sessions for all participants (see Table 5.1). Data were collected as to whether the experimenter entered the session parameters as per the session log, provided the participant with attention during the session, and correctly recorded the output data totals on the session log. Levels of procedural integrity were 100% across participants.

Table 5.1. Procedural fidelity data for study 2.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Sessions</th>
<th>Percentage of Sessions</th>
<th>Average Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dante</td>
<td>7</td>
<td>26.92</td>
<td>100.00</td>
</tr>
<tr>
<td>Pru</td>
<td>4</td>
<td>36.36</td>
<td>100.00</td>
</tr>
<tr>
<td>Nate</td>
<td>3</td>
<td>25.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Procedures

The purpose of study 2 was to determine the effects of a commitment response on the children’s self-control with task completion. Two conditions, baseline and commitment, were compared using a concurrent schedules design embedded within a
reversal design. Each session began with forced-choice trials to experience the contingencies associated with each task alternative and if available, the commitment response. The procedures for this study were the same for each participant; however, values for each parameter and the commit delay (see T in Figure 5.2) were individualized.

**Baseline.** Figure 5.1 diagrams the procedures of a baseline trial. Procedures were similar to those of the self-control assessment. Each trial consisted of a choice between an immediate and delayed task that also differed by either magnitude (Dante and Nate) or task difficulty (Pru).

![Baseline Diagram](image.png)

Figure 5.1. Components of a baseline trial for the commitment assessment trial across time where D is the value of the delay to the later alternative.

**Commitment.** Figure 5.2 diagrams the procedures for a trial during the commitment condition. All procedures for this condition were identical to those during baseline, except prior to the choice screen, the opportunity to engage in a commitment
response was provided. At the start of each trial, a commitment button appeared in the center of the computer screen for 5 s. Clicking on the commit button resulted in the removal of the button and a commit delay (i.e., T in Figure 5.2, where T = 30 s and 45 s for Dante, 30 s for Pru, and 10 s for Nate). Following the commit delay, the choice screen was not presented; instead, the immediate task was presented. If the participant did not click the commit button, following the same commit delay (i.e., T in Figure 5.2), the choice screen was presented with the same alternatives as in the baseline condition.

Figure 5.2. Components of a commitment choice trial where T is the commit delay and D is the trial delay.
Chapter 6:

Study II: Commitment Response

Results & Discussion

Dante

Results from the commitment assessment for Dante are presented in Figure 6.1. In the first phase, when the opportunity to commit was available and the commit delay was 30 s, levels of the commitment response were moderate to high (M=75%; range, 60% to 100%). During trials when the commitment response did not occur, Dante selected the delayed alternative (M=15%; range, 0% to 20%) more often than the immediate alternative (M=10%; range 0% to 20%). During the second phase, when the commitment alternative was not available, Dante’s choice of the delayed alternative immediately increased and remained at moderate levels (M=55%; range 40% to 60%). Reintroduction of the commitment alternative, beginning at session 9, resulted in overall allocation towards the commitment response but with variable levels (M=77.78%; range, 40% to 100%). During trials when commitment responses did not occur, allocation was overwhelmingly towards the delayed alternative (M=20%; range, 0% to
60%) with choice of the more immediate alternative occurring during only one trial. Moderate levels of choice of delayed alternative (M=60%) were recaptured during phase 4 when the commitment alternative was not available. In the final phase, the commitment response was reintroduced with a 45 s commit delay. High levels of commitment responses occurred throughout the phase (M=90%; range, 80% to 100%), with levels at 100% for the final two sessions. Choice of the delayed alternative occurred during every trial that Dante did not engage in the commitment response.

Figure 6.1. Percentage of choices of delayed, immediate, and commit alternatives during the commitment assessment for Dante. Phase labels indicate the commit delay (T, in seconds), the delay values (in seconds), and the task magnitude associated with each choice.
Figure 6.2. Percentage of choices of delayed, immediate, and commit alternatives during the commitment assessment for Pru. Phase labels indicate the commit delay (T, in seconds), the delay values (in seconds), and the task difficulty levels for each alternative associated with each choice.

**Pru**

Results from the commitment assessment for Pru are presented in Figure 6.2. During the first phase, when the commitment response was available with a 30 s commit delay, Pru allocated most of her responses towards the commitment response (M=80%; range, 60% to 100%). On trials during which Pru did not engage in the commitment response, she always chose the immediate alternative. When the opportunity to commit
was removed (beginning at session 5), Pru always chose the delayed alternative.

Following the reintroduction of the commitment response alternative, Pru committed to
the immediate alternative 100% of trials for four consecutive sessions.

**Nate**

Figure 6.3 depicts the results of Nate’s commitment assessment. During phase
1, when the commit delay was 10 s, commitment responses increased from moderate to
high levels across the phase (M=80%; range 60% to 100%). When Nate did not engage
in the commitment response, the delayed alternative (M=15%; range, 0% to 20%) was
selected more often than the immediate alternative (M=5%; range 0% to 20%).

Following the removal of the opportunity to commit during phase 2, choice of the
delayed alternative (M=60%) occurred at moderate and stable levels. Commitment
responses occurred during every trial for 4 of 5 sessions (M=96%) once the commitment
response was reintroduced during phase 3. During the one trial that a commitment
response did not occur, the delayed alternative was selected.
Discussion

The purpose of the study 2 was to examine the effects of a commitment response on self-control. For all participants, the results of this study showed that the opportunity to commit to the more immediate aversive event resulted in increased self-control. During the commitment condition, levels of commitment responses were high for all participants. In contrast, during baseline when the opportunity to commit was not
available, all participants demonstrated low levels of self-control, preferring delayed task completion.

The findings of this study are consistent with those of basic research involving non-human participants. For instance, Deluty et al. (1983) found that given the opportunity, rats would commit to a smaller more immediate shock to avoid a larger delayed shock. In addition, Deluty et al. found that the likelihood of a commitment response increased as a function of the extent of the commit delay. Similar results were observed in the present study for Dante. That is, when the commit delay was 30 s, Dante demonstrated moderate levels of commitment responses. However, in the final phase of the commitment assessment, when the commit delay was 45 s, higher and more stable levels of commitment responses occurred, representing an increase in self-control.

Another area of similarity between the findings of the present study and those of basic research is the likelihood of self-control on trials when the commitment response did not occur. Deluty et al. (1983) found individual differences in levels of self-control at the point of choice (i.e., choice of the smaller-sooner alternative during trials when the commitment response did not occur). Levels of self-control responses were moderate for one rat and low for another irrespective of the delay value. However, for the final rat self-control responses increased from low to moderate levels as the delay increased. In the current study, Dante and Nate demonstrated low levels of self-control on trials when they did not engage in the commitment response. In addition, after the value of the commit delay was increased from 30 s to 45 s, Dante never chose the immediate alternative during trials when he did not commit. Different patterns of
responding were observed for Pru, however. Pru chose the immediate alternative during every trial that she did not engage in the commitment response. One possible explanation for this difference is the extent to which the participants attended to the computer screen. During the commitment condition, the commit button was available for 5 s. Therefore, if the participant did not attending to the screen, the likelihood was high that the opportunity to commit would be missed. On trials during which Pru did not commit, often, she vocalized that she had “missed the button,” suggesting that she had not been attending to the computer screen. In addition, the increasing trend in commitment responses suggests that attending may have been reinforced by the opportunity to commit.
General Discussion

The purpose of this study was to examine variables that affect self-control within the context of academic task completion by elementary school children. Study 1 examined the effects of manipulating task magnitude, task difficulty, and delay to task completion on self-control whereas study 2 examined the effects of a commitment response on self-control. The findings indicated that both interventions increased self-control with aversive events.

Applied Implications

Although translational in nature, these findings provide several directions for application in applied contexts. The findings of study 1 suggest that identifying which task parameters a student’s choice is sensitive to and placing those parameters in competition with task delay may increase self-control. For instance, if results of the task parameter assessment indicate that task magnitude is meaningful for a given student, the teacher could break tasks into smaller parts. Then the student could be provided a choice between completion a portion of the task immediately or the entire task following a brief delay. After completion of each portion of the task, the teacher could again provide the choice of completion of another part of the task immediately or the
remainder of the task following a brief delay. A similar procedure may be effective if task difficulty is identified as the parameter to compete with delay to task completion. For example, a student could be asked to choose between completing a task immediately with assistance (e.g., use of a number line, calculator, dictionary, peer) or completing the task later without assistance. The findings of study 2 suggest that providing opportunities to commit to immediate task completion will promote self-control. In the classroom, commitment responses could be incorporated into situations where students are allowed to choose the order in which they complete several tasks. For instance, many classrooms precede morning work intervals with warm up activities and a snack. As such, the teacher could ask a student to select the order of his/her morning work immediately upon arrival to school thereby using the warm up activities and snack to create the delay to both alternatives. This may increase the likelihood that the student will commit to completing the more aversive tasks sooner in the day.

A second application of these findings is combining interventions to increase self-control with consequence based interventions, such as DRA and escape extinction. Although self-control increased for all participants in the present study, some variability was observed in their responding. In addition, increasing self-control may only reduce the motivating operation for escape behavior, not remove it completely. As such, escape extinction may be necessary to ensure task completion. However, it is possible that increasing the likelihood of self-control with aversive events will help mitigate the side effects of extinction. For instance, several studies have suggested that escape extinction is a necessary component in the treatment of food refusal (e.g., Cooper et al.,
1995; Reed et al., 2004). Identifying sensitivity to various bite parameters (i.e., size of the bite, consistency of the food) may inform ways to increase self-control with bite acceptance by varying those parameters across bites that are accepted and bites that require the use of escape extinction.

Both interventions suggest ways of increasing compliance with novel tasks. For instance, many academic tasks when first presented require large amounts of time and effort to complete (e.g., reading). However, as students become more proficient, the time response effort required to complete these tasks may decrease potentially making these tasks less aversive. Interventions that increase self-control may be one approach for attenuating the aversiveness of early completion of these tasks.

**Limitations and Directions for Future Research**

Despite positive findings, there are several limitations with this study. For instance, during the task avoidance assessment, Dante did not demonstrate a preference for either alternative, suggesting that completion of mathematics problems was not an aversive event. However, clear preferences were observed for low magnitude tasks and delayed task completion. In addition, low levels of self-control were observed during some phases of the self-control assessment. It is possible that the task avoidance assessment did not capture the extent to which mathematics problem completion was aversive for Dante. For instance, although task completion may be aversive for Dante, so too may be a break to nothing, resulting in the observed indifference. In the current study, a break void of attention and activities was necessary to control for extraneous variables but in the natural environment such is not the case. In addition, choice
arrangements measure relative preference. In the task avoidance assessment, task completion was as aversive as the break for Dante. However, when both alternatives required task completion, clear preferences emerged.

Another limitation is that levels of mathematics problems were not mutually exclusive. For instance, all problems that were included in the single-digit addition sums below 9 category were included in the single-digit addition sums below 19 category. As a result, when these levels were placed in direct competition, it is possible that the mathematics problems presented by the computer program did not differ significantly across alternatives. For instance, during Pru’s self-control assessment, manipulations in task difficulty did not result in a change in response allocation. It is possible her responding was not affected, because the probability of a low difficulty mathematics problem in the delayed alternative was similar to that of the immediate alternative. In the future, investigators should ensure that there is no overlap across levels of mathematics problems.

Future studies may want to assess preference across task parameters. For instance, during study 1 when task difficulty varied across alternatives, changes in the delay to both alternatives did not affect Pru’s self-control. Pru’s allocation changed immediately following a magnitude manipulation, however. It may have been beneficial to include a phase in which task magnitude and task difficulty levels were placed in direct competition during the task parameter assessment. For instance, Neef & Lutz (2001) used an assessment similar to this when designing interventions to increase the self-control with reinforcing events for two adolescents diagnosed with ADHD.
After demonstrating preference for high and low values of reinforcer rate, quality, delay, and response effort, each dimension was placed in direct competition with the other dimensions. This comparison identified the reinforcer dimension that was most likely to compete with reinforcer delay. In the present study, the results of such a comparison might have indicated that Pru’s choice was more sensitive to task magnitude than task difficulty, better informing the self-control assessment.

The current study assessed a limited number of values for each of the task parameters. For instance, in study 1 both magnitude and difficulty level had only three values: low, medium, and hard. In the case of task difficulty, the software program and the skill level of the participants limited the number of levels available. As such, difficulty manipulations for Krista and Pru were limited and only moderate changes in Krista’s self-control and no change in Pru’s self-control were produced. In addition, only one delay value was assessed for Krista and Nate, while three values were assessed for Dante and Pru. Although, additional delay values could have been assessed for both Dante and Pru, the purpose of the study was to determine whether self-control would be affected by changes in task parameters. Future studies should assess a larger sample of parameter values to determine the extent of changes in self-control across a range of values.

Another topic for future research is to examine the effect of parameter manipulations and availability of a commitment response when the probability of the occurrence of the delayed alternative varies. In the current study, the probability of the delayed alternative if chosen was one. However, many situations in the natural
environment involve choices similar to those of the current study, but the delayed alternative occurs at a probability other than one. For instance, forgoing regular dental cleanings does not guarantee that a root canal will be needed sometime in the future. Rather, the likelihood increases. Although many behavior intervention plans program escape extinction or punishment on a FR1 schedule, in reality, the probability of these interventions being implemented may be lower than one due to integrity failures and situations where it may not be possible to implement the intervention safely. Understanding the extent to which changes in probability affect self-control with aversive events would be important when programming interventions.

Finally, future research should examine the extent to which once taught, a repertoire of self-control generalizes and maintain. In the present study, all participants demonstrated increased levels of self-control, but these changes appeared to be transient in nature. For instance, low levels of self-control were quickly recaptured during reversal phases for all participants. It should be noted that the phases in both studies were brief. It is possible that continued exposure to training trials will facilitate self-control in other situations. The ultimate utility of any intervention that increases self-control with aversive events would be one that results in a generalized repertoire.
References


Appendix A: Recruitment Letter
Dear parent or guardian,

My name is Christopher Perrin, and I am currently a doctoral student at The Ohio State University. I am conducting a study under the supervision of my advisor, Dr. Nancy Neef. The purpose of the study is to examine the effects of changing various aspects of a task, such as how hard it is or how large it is, as a means of increasing student’s choice of immediate over delayed task completion. Currently, I am in the process of recruiting students who would benefit from additional practice at completing math problems to participate in this study.

Please carefully read the attached consent form, which provides important information regarding the activities that your child would participate in and the information that would be needed if you consent to his/her participation, the time commitment, and other information regarding the study. If you have any questions or would like further information, please feel free to contact me by telephone at 614 586-8318. If after reading the consent form, you are interested in having your child participate in the study, please complete and sign the consent form and return it to the locked box with my name (Christopher Perrin) on it, located in the front office of your child’s school.

Sincerely,

Christopher Perrin, M.S.Ed, BCBA
PhD student
The Ohio State University
Appendix B: Consent Form
The Ohio State University Parental Permission
For Child’s Participation in Research

Study Title: Effects of task magnitude, difficulty, and delay on self-control with task completion
Researcher: Nancy A. Neef, PhD & Christopher J. Perrin, MS.Ed

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child’s participation is voluntary.
Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The purpose of the study is to examine the effects of manipulating task magnitude, delay, and difficulty on choice between completing an immediate or delayed task.

Procedures/Tasks:
Upon receiving a signed consent form, your child’s teacher will be asked about your child’s math proficiency to determine whether your child would benefit from participation in this study.

Prior to participation in the study tasks, a math skill assessment will be conducted to determine levels of math problems that your child finds easy, moderately hard, and hard. To determine your child’s proficiency, s/he will complete several 3-minute probes each one focusing on a different type of math problem. Math problems will be presented one at a time.

All remaining tasks involved in this study will be completed using a computer program that presents choices between various math tasks. Each session will last approximately 5-10 minutes based upon your child’s choices. Approximately every minute, your child will be asked to choose between the available tasks and then complete the task of their choice.

First, a task avoidance assessment will be completed during which your child will be asked to choose between taking a break and completing a math task. The purpose of this task is to demonstrate that given a choice between completing a math task and taking a break, your child will choose to take a break.
The final part of the study consists presenting choices between various math tasks to try to increase your child’s choice of immediate task completion. There are several conditions to this study each of which presents a different choice. The choices presented will include a) completing a task now or completing the same task after a short delay, b) completing easy tasks now versus completing hard tasks now, and c) completing small tasks now versus completing large tasks now. The purpose of these conditions is to determine whether your child will consistently choose small, easy, and delayed tasks. Finally these task parameters will be varied in an attempt to increase your child’s choice of completing immediate math tasks. These variations will include choices between a) completing a small task now versus completing a large task after a short delay, b) completing an easy task now versus completing a hard task after a short delay, and c) completing a small, easy task now versus completing a large, hard task after a short delay. In the final comparison, your child will be offered an opportunity to commit to completing the immediate math task before the choice is offered as a means of increasing completion of immediate math problems.

Duration:

The length of time that your child participates in the study will be determined by your child’s choices but should not exceed two months. The math assessment and task avoidance assessment should each be completed in one to two days. The pre-assessment should be completed in one to two weeks. The self-control assessment should be completed in two to four weeks.

Your child may leave the study at any time. If you or your child decides to stop participation in the study, there will be no penalty and neither you nor your child will lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University or Helping Hands Center for Special Needs.

Risks and Benefits:

Participation in this study will expose your child to no more risk than that associated with a typical classroom situation.

There are several benefits that may result from participation in the study. First, participation in the study will provide your child with additional practice at arithmetic. Second, the results of the study may identify the best way to arrange tasks to increase the likelihood that your child will complete the tasks.

Confidentiality:

Efforts will be made to keep your child’s study-related information confidential. All identifying information will be separated or removed from the data. In addition, all consent forms and coded data will be stored separately in a locked filing cabinet of a locked office on the OSU campus. Following the completion of the study, all identifying information will be separated from the data. The data will be retained for five years following publication after
which it will be destroyed. Only the investigators will have access to the data. However, there may be circumstances where this information must be released. For example, personal information regarding your child’s participation in this study may be disclosed if required by state law. Also, your child’s records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;

Incentives:

There are no incentives that will be provided for participation in this study.

Participant Rights:

You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you or your child is a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study.

Refusing or withdrawing consent will not influence their academic standing or relationship with any school staff or investigators in any way.

An Institutional Review Board responsible for human subject’s research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study you may contact Christopher J. Perrin.

For questions about your child’s rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If your child is injured as a result of participating in this study or for questions about a study-related injury, you may contact Christopher J. Perrin.
Signing the parental permission form

I have read (or someone has read to me) this form and I am aware that I am being asked to provide permission for my child to participate in a research study. In addition, I am providing consent for my child’s teacher to share information concerning my child’s math proficiency with researchers. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

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Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

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