A Comparison of the Effects of Choice and Differential Reinforcement on the Computation Fluency of Students with Escape-Maintained Academic Performance Problems

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A Comparison of the Effects of Choice and Differential Reinforcement on the Computation Fluency of Students with Escape-Maintained Academic Performance Problems

by

Maureen A. O’Connor

A DISSERTATION

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A Comparison of the Effects of Choice and Differential Reinforcement on the Computation Fluency of Students with Escape-Maintained Academic Performance Problems

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This dissertation compared antecedent- and consequence-based strategies to determine which treatments or combination of treatments produced the strongest improvements in math computation fluency with four elementary-aged students who displayed escape-motivated behaviors. Functional analyses were conducted to identify elementary-school students whose academic responding was under a negative-reinforcement contingency. Next, a preference assessment was administered to each student to identify potentially effective reinforcers in the form of permissible school activities. These high-preference activities were used during the DRA and Task-Choice + DRA conditions. A multielement design was used to examine the impact of four treatments – Task Choice, DRA, Task Choice+DRA, and DNRA – on each student’s rate of correct digits per min.

Conditions were implemented with a high degree of integrity, and results demonstrated that all four treatments were effective and produced differentiated patterns of responding across students. For two of the students, DNRA produced noticeably higher rates of correct digits per min, whereas for a third student, there was overlapping data series between the DRA and DNRA conditions, but summary statistics indicated the
highest mean rates of correct digits per min occurred in the DNRA condition. Moreover, for the fourth student, the highest rates of correct digits per min were obtained for the DRA and Task-Choice+DRA conditions. Results were discussed in terms of the effectiveness of choice relative to reinforcement procedures, whether there were additional benefits to combining treatments, and which type of reinforcement procedures (DRA or DNRA) were more effective. Discussion also focused on the need for future research comparing functionally appropriate treatments for other forms of academic responding.
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CHAPTER 1

Introduction and Review of Literature

Academic Performance Problems in Mathematics

Despite overall improvement in mathematics achievement throughout the years, American students continue to perform poorly compared to national standards and in international comparisons (Aud et al., 2012; National Mathematics Advisory Panel [NMAP], 2008). For example, according to the National Center for Education Statistics (NCES), in 2011 only 40% of fourth-grade students and 35% of eighth-grade students in the United States were performing at or above the proficient level in mathematics. Additionally, there has been a significant mathematics achievement gap faced by students from low-income and minority backgrounds (e.g., Hispanics, Blacks, American Indian/Alaska Natives) compared to their white and Asian/Pacific Island counterparts (NCES, 2011; NMAP, 2008). Moreover, students with disabilities have not experienced improvement in mathematics at rates that are comparable to their non-disabled peers (Chard, Ketterlin-Geller, Jungjohann, & Baker, 2010).

In an effort to help improve students’ performance in mathematics, the National Council of Teachers of Mathematics (NCTM, 2000) outlined five content standards that should guide curriculum development and selection as part of a high-quality school mathematics program. These standards included (1) number and operations, (2) algebra, (3) geometry, (4) measurement, and (5) data analysis and probability (NCTM, 2000). The number and operations standard, which encompasses number sense, the meaning of basic arithmetic operations, and computation fluency, provides the basic foundation for the remaining four standards (NMAP, 2008). In particular, computation fluency is critical to
the development of other mathematical skills (NCTM, 2000; NMAP, 2008; Shapiro, 2004).

Computation fluency is the ability to calculate math facts (e.g., addition, subtraction, multiplication, or division) accurately, quickly, and with minimal effort (NCTM, 2000). Since most advanced mathematics skills require students to respond to basic math facts, students who demonstrate computation fluency may be able to allocate more cognitive resources (e.g., working memory, attention) to understanding advanced skills, increasing their likelihood of acquiring them (Gagne, 1983; Pellegrino & Goldman, 1987). Also, researchers have suggested that students who demonstrate computation fluency may be more likely than dysfluent students to choose to engage in complex math tasks and experience lower levels of anxiety related to mathematics (Billington & DiTommaso, 2003; Cates & Rhymer, 2003; McCurdy, Skinner, Grantham, Watson, & Hindman, 2001; Skinner, 1998). Conversely, students who lack computation fluency may try to avoid complex math tasks due to the time and effort required to complete them and/or the perception that they are too difficult to successfully complete (Skinner, Pappas, & Davis, 2005). Failure to acquire computation fluency can also be associated with long-term negative outcomes, including being excluded from vocational and career opportunities that require these math skills (NMAP, 2008).

Given the fact that computation fluency is a prerequisite to developing more advanced mathematical skills and that negative outcomes (e.g., high levels of anxiety related to mathematics, avoidance of complex math tasks, inability to complete activities of daily living that require math-fact acquisition and fluency) have been associated with dysfluency, it is important to develop and implement effective interventions to improve
students’ computation fluency (Cates & Rhymer, 2003; NCTM, 2000; NMAP, 2008; Skinner et al., 2005). In order to identify effective interventions for increasing students’ computation fluency, it is essential to first examine why academic performance problems exist (Daly, Hofstadter, Martinez, & Anderson, 2010). With this information, interventions can then be designed that appropriately address the function of these problems.

**Behavior-Analytic Explanation of Academic Performance Problems**

The basic behavioral process that governs academic responding is stimulus control (Daly & Murdoch, 2000). Within a stimulus-control paradigm, academic responding comes under the control of a relevant instructional antecedent (e.g., computation problems) through stimulus-discrimination training (Miltenberger, 2012). According to Skinner (1969), stimulus-discrimination training involves a three-term contingency (antecedent-behavior-consequence) whereby an individual’s behavior is followed by a reinforcing consequence only in the presence of a particular antecedent stimulus called the discriminative stimulus (S\textsuperscript{D}). Whenever the individual’s behavior occurs in the presence of other antecedent stimuli (S-delta), it is not reinforced (Kazdin, 1980; Miltenberger, 2012; Spradin & Simon, 2011). As a result of stimulus-discrimination training, there is a greater likelihood that the individual’s behavior will occur again in the presence of the S\textsuperscript{D} but not in the presence of an S-delta (Kazdin, 1980; Miltenberger, 2012; Skinner, 1953). The S\textsuperscript{D} occasions a particular behavior because of its prior association with reinforcement contingent on that behavior, whereas an S-delta signals that a particular behavior is not likely to be reinforced (Baer, 1997; Kazdin, 1980; Miltenberger, 2012; Spradin & Simon, 2011). Although the S\textsuperscript{D} evokes a particular
behavior, ultimately it is the consequences that control the future occurrence of the behavior (Maag, 2004; Miltenberger, 2012; Skinner, 1969). That is, a behavior that produces desirable consequences is more likely to be repeated in the future under similar conditions (Miltenberger, 2012). Therefore, in order for stimulus control to develop, there must be some type of positive reinforcement.

A behavior is considered to be positively reinforced when its occurrence results in the presentation of a stimulus (i.e., a positive reinforcer) which strengthens or increases the future occurrence of that behavior (Kazdin, 1980; Maag, 2004; Miltenberger, 2012). For example, every time a student completes 5 addition problems, the teacher gives the student a high five and says “great job working on your basic math facts.” As a result of this social contact, the student continues to complete more addition problems. The student’s behavior is being positively reinforced by social attention from the teacher. As this example illustrates, positive reinforcement can be in the form of social attention (from adults, peers, or siblings) which can include things such as high fives, praise, smiles, or eye contact (Gresham, 2004; McComas & Mace, 2000). Positive reinforcement can also result in access to tangible items (e.g., food, toys) or preferred activities (e.g., playing video games, listening to music), as well as access to non-socially mediated sensory stimulation (Gresham, 2004; Gresham, Watson, & Skinner, 2001; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982; McComas & Mace, 2000).

In contrast to positive reinforcement, a behavior is considered to be negatively reinforced when the occurrence of the behavior results in the immediate removal, delay, or reduction in the intensity of an aversive stimulus or event which increases the probability that the behavior will occur in the future (Kazdin, 1980; Maag, 2004;
Miltenberger, 2012). For example, every time a student is presented with a math worksheet he proceeds to rip it up and the teacher sends him to the principal’s office. Being sent to the principal’s office allows the student to get out of doing his math worksheet, so he continues to rip up his worksheets each time the teacher gives them to him. In this example, the student’s behavior is being negatively reinforced by escape from the math worksheets (i.e., an aversive activity). Aside from escape or avoidance of aversive tasks or activities, other forms of negative reinforcement include escape from social attention (e.g., reprimands, frowns, conversations with nonpreferred peers) or non-socially mediated sensory stimulation such as hunger, sinus pain, and itching (Gresham, 2004).

Motivating operations (MOs) influence the effectiveness of positive and negative reinforcement (Miltenberger, 2012). MOs are antecedent events or conditions that impact behavior change by momentarily altering the reinforcing value (or effectiveness) of specific consequences (Laraway, Snycerski, Michael, & Poling, 2003; Miltenberger, 2012; Steege & Watson, 2009). There are two broad categories of MOs – abolishing operations (AOs) and establishing operations (EOs) (Laraway et al., 2003). AOs, such as satiation, temporarily diminish the value of a reinforcer or punisher (Laraway et al., 2003; Steege & Watson, 2009). For example, having just consumed a large meal abolishes food as a reinforcer and therefore abates the behavior of getting and eating food. Alternatively, EOs, such as deprivation, temporarily increase the value of a reinforcer and make the behavior that results in that reinforcer more likely to occur (Keller & Schoenfeld, 1950; Michael, 1982, 1993; Miltenberger, 2012; Steege & Watson, 2009). For instance, being
deprived of food for an entire day establishes food as a reinforcer and consequently evokes the behavior of getting and eating food.

The presence of an academic performance problem indicates that the $S^D$ (i.e., the instructional antecedent such as computation problems) has not developed stimulus control over the student’s academic responding, suggesting that the current instructional arrangement is not functionally relevant to the student’s skill level (Kupzyk, Daly, Ihlo, & Young, 2012). For example, the student may not have received enough help to successfully perform the academic task (Daly, Martens, Witt, & Dool, 1997). That is, some students may lack the necessary skills to perform an assigned task (i.e., they have a skill deficit) and, consequently, require additional instructional strategies (e.g., prompting, feedback, error correction, multiple opportunities to respond) during instructional time in order to improve their skill level so that academic responding can occur and subsequently be reinforced (Daly et al., 2010; Duhon et al., 1994; Heward, 1994; Jones & Wickstrom, 2010; Shapiro, 2004). Alternatively, the academic tasks might be too difficult (i.e., they do not match the student’s current skill level), resulting in insufficient or nonexistent levels of responding (Daly et al., 1997). The importance of matching instructional materials to a student’s skill level has been well-documented in the literature (e.g., Daly, Martens, Kilmer, & Massie, 1996; Treptow, Burns, & McComas, 2007). For example, Gickling and Armstrong (1978) found that students’ on-task behavior, task completion, and accuracy of assigned work was significantly higher when provided materials at their instructional level versus their frustrational level. Similarly, Gilbertson, Duhon, Witt, and Dufrene (2008) demonstrated that students’ on-
task behavior and math computation fluency improved when they worked on instructional level versus frustrational level materials.

However, in other instances, a student’s academic responding may be under the appropriate stimulus control but his or her low academic performance is related to the reinforcement contingencies that are in place. That is, the consequences for academic responding (e.g., praise from the teacher, rewards for work completion) might not be powerful enough or may be too infrequent to compete effectively with the available reinforcement for engaging in undesirable behaviors (e.g., talking to peers, walking around the classroom without permission, playing with objects at their desk) during instructional tasks (Daly et al., 2010). Therefore, the reinforcement contingencies must be rearranged to promote academic responding and to extinguish undesirable behaviors that exacerbate academic performance problems. To aid in this endeavor, a functional analysis should be conducted to identify the reinforcement contingencies maintaining a student’s low academic performance (O’Neill et al., 1997).

**Functional Analysis**

Functional analysis involves the systematic manipulation of environmental variables (antecedents and consequences of behavior) in order to empirically demonstrate a functional relationship between the environmental variables and a student’s problem behavior (Iwata et al., 1982; Miltenberger, 2012; O’Neill et al., 1997; Steege & Watson, 2009). Functional analysis was originally developed by Iwata et al. (1982) in their study of self-injurious behavior (SIB). Using a multielement design, the researchers exposed each participant to four experimental conditions – attention (the experimenter provided social attention to the participant contingent on the occurrence of the problem behavior),
escape (the experimenter removed an academic task from the participant contingent on engagement of the problem behavior), control (the experimenter provided noncontingent access to social attention and tangible items), and automatic reinforcement (the participant was alone in a room that lacked stimulation such as toys, materials, and other tangibles). For each of these conditions, two 15-min sessions were conducted per day (one in the morning and one in the afternoon) over a period of several weeks. In order to determine the function of a participant’s behavior, the authors graphed the participants’ SIB under each experimental condition and used visual analysis to identify the condition(s) in which the SIB occurred at the highest rate compared to the control condition (Betz & Fisher, 2011; Gresham et al., 2001).

Functional analysis has since emerged as an effective method for identifying maintaining variables such as social positive reinforcement (attention or access to tangibles or activities), negative reinforcement in the form of escape from instructional demands or other sources of aversive stimulation, and non-socially mediated sensory stimulation (Miltenberger, 2012; Steege & Watson, 2009). For example, Iwata et al. (1994) conducted functional analyses on 152 individuals with developmental disabilities who exhibited SIB and discovered that escape from instructional demands or tasks was the most prevalent function (38.1%) for their SIB, followed by social positive reinforcement (26.3%), non-socially mediated sensory stimulation (25.7%), and a combination of positive and negative reinforcement (5.3%). Similarly, Wacker et al. (1998) identified negative reinforcement in the form of escape from instructional demands or tasks as the primary function (46%) of the aberrant behavior (e.g., SIB, aggression, property destruction, stereotypy) of 32 children with developmental delays or
multiple disabilities. The remaining functions identified included social positive reinforcement (21%), a combination of positive and negative reinforcement (18%), and non-socially mediated sensory stimulation (4%). Finally, Asmus et al. (2004) found that the maintaining variables for the aberrant behavior (e.g., SIB, aggression, property destruction, stereotypy) of 138 children and adults with and without developmental disabilities included a combination of positive and negative reinforcement (40%), negative reinforcement (29%), positive reinforcement (12%), non-socially mediated sensory stimulation and positive reinforcement (8%), and non-socially mediated sensory stimulation (7%). As these and other studies have consistently demonstrated, functional analysis successfully identifies controlling variables for the vast majority of cases.

Over the past three decades, the clinical utility and experimental rigor of functional-analysis procedures has been validated by several researchers (Beavers, Iwata, & Lerman, 2013; Hanley, Iwata, & McCord, 2003; Steege & Watson, 2009). These procedures have been successfully applied to a wide range of settings and diverse populations. For example, functional analysis has been conducted in outpatient clinics (e.g., Northup et al., 1991; Stephens, Wacker, Cooper, Richman, & Kayser, 2003), inpatient psychology units of hospitals (e.g., Call, Wacker, Ringdahl, & Boelter, 2005), homes (e.g., Arndorfer, Miltenberger, Woster, Rortvedt, & Gaffaney, 1994), and even schools (e.g., Broussard & Northup, 1995; Northup et al., 1994). With respect to school populations, functional-analysis procedures have been effectively used to identify the function of problem behavior displayed by typically developing students in a general education classroom (e.g., Doggett, Edwards, Moore, Tingstrom, & Wilczynski, 2001; Northup et al., 1994; Skinner, Veerkamp, Kamps, & Andra, 2009; Wright-Gallo, Higbee,
Reagon, & Davey, 2006) as well as children classified with disabilities such as behavior disorders (e.g., Wright-Gallo et al., 2006) and Attention Deficit Hyperactivity Disorder (e.g., Skinner et al., 2009). For example, Ellis and Magee (1999) used a multielement design to examine the effects of analog and in-class functional-analysis conditions – peer attention, peer competition for teacher attention, play, escape, and alone – on the problem behavior (e.g., non-compliance, aggression, SIB, yelling) of three elementary-aged students with emotional and behavioral disorders. In the peer-attention condition, a peer provided social attention to the students contingent on the occurrence of problem behavior. During the peer-competition-for-teacher-attention condition, the teacher provided social attention to a peer and ignored the students until the occurrence of problem behavior, at which point the teacher provided social attention to the students in the form of a reprimand. The play condition served as the control condition and consisted of noncontingent access to tangibles and the provision of social attention from the teacher once every min. In the escape condition, during the analog sessions, the teacher instructed the students to work on academic tasks (e.g., reading, solving math problems) that were reported to be difficult for the students. For two of the students, the teacher provided instructions every 1 min. For the third student, the teacher provided instructions every 10 s. During the in-class sessions, the teacher gave the students an academic assignment and provided specific instructions (e.g., work faster, write more neatly) every min. Across the analog and in-class sessions, the teacher provided immediate performance feedback to the students. Additionally, contingent on the occurrence of problem behavior, for two of the students, the task was removed for 1 min. For the third student, the task was removed for
The functional analysis results indicated that the students’ problem behavior was being maintained by different controlling variables.

In another application of functional analysis methodology to the academic context, Shumate and Wills (2010) conducted functional analyses for three elementary students identified as at-risk for reading failure and identified the function of their disruptive and off-task behavior during reading instruction. In this study, each student was exposed to three experimental conditions – attention, escape, and control – during the functional analysis. In the attention condition, the teacher instructed the students to start reading at the beginning of the reading class, monitored the classroom as usual, and provided social attention contingent on the occurrence of disruptive or off-task behavior. During the escape condition, every 30 s the teacher instructed the students to engage in reading and provided a brief verbal praise statement if they complied with the request. If the students did not comply with the request within 5 s, the teacher prompted the student to begin/continue reading. If this prompt was followed, the teacher provided a brief verbal praise statement. However, if the students did not comply with the prompt within 5 s, the teacher removed the reading materials from the student until the next 30-s interval, at which time the instructional demand was re-presented. In the control condition, the teacher allowed the student to read a book of his or her preference and provided noncontingent access to social attention. For each of these conditions, one 5-min session was conducted per day during the students’ typical reading instruction. For all three students, visual analysis of the results revealed that higher levels of off-task and disruptive behavior were observed in the attention condition, suggesting that teacher attention functioned as the maintaining variable for the students’ problem behavior.
The majority of functional analysis research has primarily focused on contingencies maintaining problem behavior (Gable, Hendrickson, & Sasso, 1995). A limited number of studies have applied functional-analysis procedures to students’ academic responding (i.e., a replacement behavior). In one such investigation, Broussard and Northup (1995) conducted functional assessments and analyses to examine the impact of teacher attention, peer attention, and escape from academic tasks on the disruptive behavior and academic work completion and accuracy of three elementary-aged students. Descriptive assessments consisting of classroom observations, interviews with the teachers, and record reviews were first conducted to identify one of three hypotheses—teacher attention, peer attention, or escape from academic tasks—regarding the function of the students’ disruptive behaviors. The selected hypothesis was then evaluated by conducting a functional analysis. Using a reversal design, contingent and noncontingent reinforcement conditions were implemented for each student, with the hypothesized maintaining variable serving as the reinforcer for disruptive behavior. These conditions were followed by a contingency reversal whereby an alternative, desirable behavior (i.e., academic work completion and accuracy) was reinforced and disruptive behavior was placed on extinction. The results demonstrated that in each case, the functional analysis confirmed the hypothesized function of the students’ disruptive behavior. Additionally, contingency reversals indicated that the maintaining variable was an effective reinforcer for alternative, desirable behavior. Although this study was one of the first investigations to use functional analysis to address students’ academic responding, academic responding served as the dependent variable only during the contingency reversal. The researchers did not target academic performance in all
conditions in the functional analysis. In general, within the functional analysis literature, conditions directly targeting academic responding have not been included in these studies.

More recently, Hofstadter-Duke (2012) conducted functional analyses to determine whether differentiated function could be identified when typical functional analysis contingencies were applied to academic responding—specifically, math computation. Functional analyses were carried out first with unknown computation problems (not yet acquired) and then with known computation problems. To this end, she exposed students to four functional-analysis conditions – teacher attention, peer attention, escape, and control – and reinforced mathematics performance across both problem types (known and unknown). Using a multielement design, two functional analyses were conducted with each student to examine the impact of the reinforcement conditions on rate of completed problems and rate of digits correct, academic engagement, and disruptive behavior. The functional analyses for both types of problems were conducted using the same procedures. In the first functional analysis (containing unknown problems) results were undifferentiated for all outcomes for all participants. Prior to the second functional analysis, students received instruction with a set of unknown math problems until 80% of math facts were answered correctly, creating a set of “known” math problems that were used during the second functional analysis. In this set of functional analyses, differentiated responding was obtained for all three students for at least one dependent variable. For one student, relative to the escape and control conditions, teacher attention produced higher rates of completed problems, digits correct, and academic engagement. Similarly, for a second student, the teacher-attention
condition was associated with higher rates of completed problems and digits correct compared to the other conditions. For the third student, an overall higher rate of digits correct was obtained during the escape condition compared to the control and attention conditions. Unfortunately, disruptive behavior levels were so low during all analyses that no differentiation of conditions was obtained for this variable. To further validate the results, the single-most effective condition for each student was applied in a counterbalanced fashion to unknown and known problems for a novel mathematics skill. This final phase confirmed the results of the previous analyses; responding increased in the reinforcement condition with known problems but not in the reinforcement condition with unknown problems. This study demonstrates that it is possible to identify behavioral function when typical reinforcement contingencies are applied to already acquired (i.e., known) math computation problems.

Hofstadter-Duke’s (2012) findings extended the current functional analysis literature by demonstrating that functional analysis methodology can be applied to skill repertoires like math computation to reliably determine stimulus function. In her study, she emphasized contingency manipulation for traditionally examined stimulus functions (teacher attention, peer attention, escape, and control) to determine whether they could be generalized to an academic performance variable like math computation. The comparisons, however, were limited to the functional-analysis conditions. It is unclear whether the results of this kind of functional analysis can be used to then compare other function-based treatments. For example, multiple treatment options exist for students displaying escape-motivated behavior, raising the question of whether a method like that used by Hofstadter-Duke could be used to identify stimulus functions prior to comparing
functionally appropriate treatments. For example, if students displayed escape-motivated behavior during the functional analysis, these results could presumably be used to compare interventions that address the existing negative reinforcement stimulus function to determine which functionally appropriate treatment produces the strongest results for that student. This use of functional analysis targeting academic performance has not yet been done with the procedures developed by Hofstadter-Duke. Yet, conducting a functional analysis in this manner may significantly aid in the evaluation of function-based interventions for academic performance problems (O’Neill et al., 1997; Reschly, Coolong-Chaffin, Christenson, & Guitkin, 2007; Steege & Watson, 2009).

Selecting Functional Interventions for Academic Performance Problems

Some students exhibit academic performance problems because their responding has not come under the stimulus control of the instructional materials. In order for stimulus control to develop (i.e., the students are able to respond to an academic task accurately and quickly), additional instructional strategies must be implemented during instructional time (Daly et al., 2010; Heward, 1994). Specifically, the assistance that these students require is dependent upon their current level of proficiency in performing the academic task (Daly et al., 1997). According to the instructional hierarchy, as a student becomes proficient in performing an academic task, he or she will progress through a series of learning stages – acquisition, fluency, generalization, and adaptation (Daly, Lentz, & Boyer, 1996; Haring, Lovitt, Eaton, & Hansen, 1978). Each of these stages has different corresponding instructional strategies that promote mastery at that level (Daly, Lentz et al., 1996). Therefore, if a student has not achieved accuracy, fluency, or generalization, he or she should receive the appropriate instructional supports...
(e.g., modeling, prompting, and error correction at acquisition, opportunities to practice
the skill and reinforcement of quick responses at fluency) to enhance performance (Daly,
Lentz et al., 1996, Daly et al., 1997; Haring et al., 1978).

For other students, however, their responding to academic tasks may be under the
stimulus control of the instructional materials but a performance deficit exists whereby
the students would otherwise perform the desired skill under the right motivating
conditions, but fail to do so at an appropriate frequency, intensity, or duration which,
consequently, hinders their performance (Gresham, 2007; Jones & Wickstrom, 2010).
The main issue is that the reinforcement contingencies (e.g., high five from the teacher,
sticker for work completion) for academic responding are not frequent or strong enough
to compete effectively with the consequences for engaging in undesirable behaviors (e.g.,
talking out of turn, property destruction) that exacerbate academic performance problems.
These problem behaviors may be maintained by positive or negative reinforcement. For
example, students may make animal noises, tell jokes aloud in the classroom, or engage
in other disruptive behavior in order to gain attention from their peers and/or the teacher.
Any attention that the students receive for engaging in these disruptive behaviors
strengthens their future occurrence (i.e., these disruptive behaviors are being maintained
by positive reinforcement in the form of attention from peers and/or the teacher).
Alternatively, students may destroy classroom property, act aggressively toward peers, or
engage in other destructive behavior that leads to their removal from the classroom and
hence the removal of the instructional demands, increasing the probability that the
student will engage in these destructive behaviors in the future. As such, these problem
behaviors are being negatively reinforced in the form of escape from instructional
demands. Within the literature, researchers have found that negative reinforcement in the form of escape from instructional demands is one of the most common functions of students’ problem behavior (e.g., Asmus et al., 2004; Geiger, Carr, & LeBlanc, 2010; Iwata et al., 1994; Wacker et al., 1998). Given this prevalence, the present study focused on students whose low academic performance is maintained by escape from instructional demands.

**Consequence-based interventions.** For problem behaviors maintained by either positive or negative reinforcement, consequence-based strategies seek to alter the reinforcement contingencies in such a way that responding shifts away from problem behavior and toward desired behavior. One way this approach would work for escape-maintained behavior is to negatively reinforce appropriate behavior while putting escape-motivated problem behavior on extinction. With this strategy—referred to as differential negative reinforcement of alternative behavior (DNRA; Geiger et al., 2010)—a break from the instructional demands is delivered contingent on an alternative desired response (e.g., compliance, academic engagement, work completion) while problem behavior results in escape extinction. For example, Marcus and Vollmer (1995) implemented a DNRA procedure to decrease disruptive behavior and improve compliance in a 5-year-old girl with developmental disabilities. A functional analysis revealed that the student’s disruptive behavior was maintained by escape from instructional demands. During baseline, the student’s level of disruptive behavior was high, averaging 1.76 responses per min, and her compliance was low, averaging 12.6%. The DNRA procedure provided a 20-s break contingent on compliance to an instructional demand, and, when it was applied, the student’s disruptive behavior was significantly reduced, averaging 0.48
responses per min, and her compliance increased to an average of 75%. Similarly, other researchers have demonstrated the effectiveness of the DNRA procedure for decreasing escape-maintained problem behaviors and for improving desirable alternative behaviors (e.g., Golonka et al., 2000; Piazza, Moes, & Fisher, 1996; Vollmer, Roane, Ringdahl, & Marcus, 1999; Warzak, Kewman, Stefans, & Johnson, 1987).

Of all the available differential reinforcement procedures, DNRA would appear to be the most natural treatment of choice for escape-motivated behavior, as it involves continued access to a functional reinforcer (i.e., escape from instructional stimuli) contingent on an alternative response. Yet, some investigators have examined the effects of differential reinforcement of alternative behavior (DRA) on escape-maintained behavior. DRA entails the delivery of a functionally arbitrary reinforcer (e.g., preferred food or toys) contingent on the occurrence of an alternative response while placing escape-maintained problem behavior on extinction (Fisher & Bouxsein, 2011; Geiger et al., 2010). Carr, Newsom, and Binkoff (1980) provided a demonstration of this in their investigation of a student with mental retardation who displayed escape-maintained aggressive behaviors. In experiment 1, an A/B/A/B design demonstrated that the frequency of the student’s aggressive behaviors was high during the simple demand condition (i.e., an experimenter handed the student a buttoning board and asked him to button it every 10 s) but near zero during the no-demand condition (i.e., an experimenter handed the student a buttoning board but made no demands). These results suggested that the student’s aggressive behaviors functioned as an escape-motivated response. In Experiment 2, a DRA procedure was implemented to decrease the student’s escape-maintained aggressive behaviors and to increase his compliance. The effect of the DRA
procedure was evaluated in demand and DRA conditions using an A/B/A/B design. The demand condition was identical to the one in Experiment 1. During the DRA condition, every time the student complied with the request to button the buttoning board, an experimenter either provided 4 sec of access to a preferred toy or gave the student a preferred food item (e.g., ½ a tsp of fruit ice or a single potato chip). The student exhibited noticeably lower levels of aggressive behavior in the DRA versus the demand conditions. An important element to the DRA procedure was the identification of reinforcers for compliance through a stimulus-preference assessment (e.g. Fisher et al., 1992; Pace, Ivancic, Edwards, Iwata, & Page, 1985; Wilder, Ellsworth, White, & Schock, 2003; Windsor, Piche, & Locke, 1994). In particular, researchers have found that the multiple-stimulus without replacement (MSWO) method leads to valid selection of reinforcers for elementary school applications (e.g., Daly et al., 2009).

Researchers have compared the effects of DRA and DNRA procedures among students whose problem behaviors are escape-maintained to determine which is associated with greater treatment outcomes. In one such investigation, Lalli et al. (1999) examined the effects of positive and negative reinforcement with and without extinction on the task compliance and problem behavior of five individuals with developmental disabilities. Results of the functional analyses revealed that all five participants engaged in problem behavior (e.g., SIB or disruptive behavior) to escape an instructional demand. In the subsequent treatment analysis, compliance with an instructional demand resulted in a preferred food item (i.e., positive reinforcement) or a 30-s break from the task (i.e., negative reinforcement) while problem behavior was either placed on extinction or produced a 30-s break from the task. For all five participants, higher levels of task
compliance and lower rates of escape-maintained problem behavior were observed when task compliance produced positive versus negative reinforcement, regardless of whether or not problem behavior resulted in extinction. However, the researchers noted that one limitation to the study is that they did not evaluate if similar results would be obtained if alternative forms of positive reinforcement (e.g., social praise, leisure items) were provided contingent on compliance.

Carter (2010) replicated and extended the findings of Lalli et al. (1999) by providing other forms of positive reinforcement (e.g., low-preference food items, high-preference leisure items) contingent on compliance. In this investigation, a series of reversals was used to evaluate the effects of positive and negative reinforcement on the destructive behavior and compliance of a 19-year old male with a history of destructive behavior and profound mental retardation. The results of the functional analysis showed that the participant displayed destructive behavior to escape from self-care tasks (e.g., put on or remove jacket or shoes, wash hands, wipe face). In light of these findings, treatment consisted of reinforcing compliance to the self-care tasks with positive or negative reinforcement and providing escape for destructive behavior. Specifically, whenever the participant completed a self-care task, he either received a high-preference edible item (high-preference edible item plus escape condition) or a low-preference edible item (low-preference edible item plus escape condition) while the occurrence of destructive behavior resulted in a 30-s break. The high-preference leisure item plus escape condition was the same with the exception that the participant received a high preference leisure item (i.e., a sticker or being able to listen to the radio) contingent on compliance to a self-care task. During the escape-for-compliance-and-destructive-behavior condition, both the
completion of a self-care task and the occurrence of destructive behavior resulted in a 30-s break. Higher levels of compliance and lower levels of destructive behavior were observed when compliance resulted in access to a high-preference edible or leisure item (i.e., positive reinforcement) compared to a 30-s break (i.e., negative reinforcement). Similarly, Bouxsein, Roane, and Harper (2011) observed higher levels of task compliance in a student with Down’s syndrome when task completion resulted in contingent access to 60 s of music versus a 60-s break. Therefore, both forms of differential reinforcement—DNRA and DRA—have been shown to be effective with escape-motivated behavior. However, it remains unclear whether these strategies can be equally effective at improving academic responding for students whose behavior is under a negative reinforcement contingency. If they are in fact effective, it would be important to determine whether one of these reinforcement procedures is more effective than the other.

**Antecedent-based interventions.** Apart from differential reinforcement procedures, several antecedent-based interventions appear in the literature as effective treatment options for problem behaviors maintained by negative reinforcement in the form of escape from instructional demands (Smith, 2011). In general, antecedent control interventions alter some aspect of the physical or social environment in order to evoke desirable behavior or to reduce the occurrence of competing, undesirable behavior (Luisellli, 1998; Miltenberger, 2012). In doing so, they are functional, nonaversive procedures in that they produce behavior change without the use of punishment by modifying the antecedent variables that control behavior (Kern et al., 1998; Miltenberger, 2012; Steege & Watson, 2009). Antecedent-based interventions have the advantage of
forestalling problem behavior from even occurring in the first place (when effective) and therefore may be a nice alternative to consequence-based strategies which may allow problem behavior to occur until an extinction effect is achieved. Miltenberger (2012) describes three general types of antecedent-control interventions – manipulating response effort, controlling discriminative stimuli ($S^D$s), and evoking MOs. Of the three general types of antecedent-control interventions, manipulating MOs may be most appropriate for students whose problem behaviors are maintained by escape from instructional demands. For these students, instructional demands function as aversive stimuli, occasioning escape-maintained problem behavior which in turn contributes to low academic performance (Smith & Iwata, 1997). Manipulating MOs can increase the potency of reinforcement associated with completing an educational task or result in access to more preferred tasks and escape from aversive demands, thus decreasing the likelihood that students will engage in problem behaviors that allow them to escape the task. One MO manipulation that may be particularly salient for students avoiding academic tasks is the provision of choice.

In the last 30 years, researchers have demonstrated that choice as a therapeutic intervention can be applied to consequences and academic tasks to improve student behavior (e.g., Carson & Eckert, 2003; Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Dyer, Dunlap, & Winterling, 1990; Kern, Mantegna, Vorndran, Bailin, & Hilt, 2001; Kern et al., 1998; McComas, Hoch, Paone, & El-Roy, 2000; Morgan, 2006; Seybert, Dunlap, & Ferro, 1996; Stenhoff, Davey, Lignugaris-Kraft, 2008). For example, researchers have studied the effects of choice-making by manipulating choice of consequent stimuli while holding task variables constant (e.g., Geckeler, Libby, Graff, &
Ahearn, 2000; Graff, Libby, & Green, 1998; Sran & Borrero, 2010; Thompson, Fisher, & Contrucci, 1998). In one such investigation, Tiger, Hanley, and Hernandez (2006) used a concurrent-chains procedure to evaluate the effects of choice of reinforcer on the academic performance of six preschool students. In this study, in order to identify preferred edible items to be included in the choice evaluation, a preference assessment was conducted with each student. Following the preference assessment, a concurrent-chains arrangement was used whereby three colored worksheets were placed in front of a student and the experimenter prompted the student to pick one that he or she would like to work on. To control for task difficulty across the three colored worksheets, the stimuli (e.g., letters, numbers, or sight words) presented on each worksheet were identical (i.e., the yellow, blue, and orange worksheets each contained the letters J, K, L, and M). Correct responding to the selected worksheet resulted in the corresponding programmed consequence. That is, the students received praise when they selected and correctly responded to a yellow worksheet (control terminal link). The students chose one edible item from an array of five identical items (e.g., one of five red jelly beans) when they selected and correctly responded to an orange worksheet (choice terminal link). When a student selected and correctly responded to a blue worksheet (no-choice terminal link), the experimenter delivered one of the same edible items (e.g., one red jelly bean). In order to help the students to discriminate between the terminal links (i.e., the control, choice, and no-choice terminal links), prior to each session an explanation of the programmed consequences that corresponded to each colored worksheet was provided to the students in addition to two prompted exposures to each terminal link. Sessions were then conducted immediately following the prompted exposure. Results demonstrated that
allowing the students to choose the reinforcer was preferred to the other conditions (praise and an edible item selected by the experimenter) by five of the six participants and that for three of them, this preference persisted over time.

Schmidt, Hanley, and Layer (2009) conducted a systematic replication of the procedures described by Tiger et al. (2006) but presented an equal number of items across all terminal links. For instance, contingent on accurate responding, in the choice terminal link students selected one of five items (e.g., one of five red jelly beans) whereas in the no-choice terminal link the experimenter selected from these same items (e.g., one of five red jelly beans). The results supported the findings of Tiger et al. and demonstrated that choice making was favored over a no-choice condition, even when less preferred items were exclusively available. Overall, the results from these two studies suggest that students were more likely to engage in the tasks that allowed them to select the edible item they would receive for correct responding relative to tasks in which the experimenter selected the reinforcer.

There is also evidence that task choice even with low-preference tasks reduces escape-motivated behavior in some cases (e.g., Killu, Clare, & Im, 1999; Umbreit & Blair, 1996; & Vaughn & Horner, 1997). Umbreit and Blair (1996) provided a demonstration of this in an investigation evaluating the effects of choice and preference on the appropriate (e.g., on-task behavior, positive verbal and non-verbal social behavior) and problem behaviors (e.g., running away, biting, spitting) of an 11-year-old boy with moderate to severe intellectual disability. When offered a choice between two previously assessed low-preference academic tasks, the student engaged in more appropriate behavior and less problem behavior compared to when he was assigned the same
academic tasks by the teacher (no-choice). Vaughn and Horner (1997) obtained similar results in a study comparing the impact of student versus teacher choice making on the problem behavior (i.e., aggression, disruptive behavior, screaming, and non-compliance) of four students with severe disabilities. In contrast to a no-choice condition that involved having the teacher select a previously assessed low-preference academic task, an A/B/A/B design demonstrated that when the students could choose between two previously assessed low-preference academic tasks, two of them displayed moderately, yet noticeably lower levels of problem behavior. Both of these studies suggest that choice of low-preference academic tasks can even be effective at reducing problem behavior.

Dunlap et al. (1994) investigated choice by comparing it to both a no-choice condition and another no-choice condition that was yoked to the choice condition (i.e., produced the same consequence as the choice condition). The study was carried out with an elementary-aged student with a behavioral disorder. In study 1, during independent seatwork, students either chose the academic task they would work on from a menu of six to eight options (choice condition) or the teacher selected a task for them (no-choice condition). Reversal designs were then used to compare the effects of the choice and no-choice conditions. Both within and across both students, greater task engagement and lower levels of disruptive behavior were observed in the choice versus the no-choice condition. Study 2 used a yoked control procedure in order to evaluate the impact of task choice while controlling for the effects of differential preferences. In this study, an A/B/A/B design was used to compare choice and no-choice conditions during a reading activity in which the student was expected to listen to the experimenter read a book aloud. In the choice condition, the student selected the books to be read from a pool of
eight options. During the initial no-choice condition, the teacher randomly selected the books to be read from the same options that were available during the choice condition. The second no-choice condition (i.e., a yoked control procedure) was identical with the exception that the teacher did not randomly select the books to be read; rather, the teacher picked the books according to the sequence that the student had selected during the preceding choice condition. The results revealed that the student’s task engagement was higher and his disruptive behavior was lower during the choice versus the no-choice conditions. Powell and Nelson (1997) replicated the study and obtained similar results in an elementary student with Attention-Deficit/Hyperactivity Disorder.

Romaniuk et al. (2002) extended the research on choice by linking it to behavioral function. Romaniuk et al. conducted functional analyses prior to implementing an intervention involving task choice and demonstrated that the effectiveness of choice-making varied based on the function of the student’s problem behavior. In this study, functional analyses revealed that students’ problem behaviors were either maintained by attention (n = 3), escape (n = 3), or were multiply controlled by both stimulus functions (n =1). Following the functional analyses, an A/B/A/B reversal design was used to examine the effect of task choice among the six students whose problem behaviors were controlled by a single stimulus function. During the no-choice condition, the experimenter assigned an academic task for the students to work on and task assignment was counterbalanced across sessions. In the choice condition, the students selected an academic task from an array of four to six tasks and were allowed to change tasks within the session. Across both experimental conditions, in order to measure the impact of task choice independent of the effect of extinction, the occurrence of problem behavior
resulted in the consequence demonstrated during the functional analysis to maintain the problem behavior (i.e., students whose problem behavior was maintained by escape received a 10-s break, whereas students whose problem behavior was maintained by attention received a 5-s reprimand). The results indicated that within and across the three students whose problem behavior was maintained by escape, higher levels of problem behavior occurred during the no-choice condition ($M = 71\%$, $65\%$, and $69\%$ of session for students A, B, and C, respectively), whereas discernibly lower levels of problem behavior were evident in the choice condition ($M = 8\%$, $23\%$, and $27\%$ of the session for students A, B, and C, respectively). In contrast, for the three students whose problem behavior was maintained by attention, problem behavior remained at similar levels during the choice ($M = 20.9\%$, $88\%$, and $71\%$ of the session for students D, E, and F, respectively) and no-choice conditions ($M = 15.3\%$, $71\%$, and $63\%$ of the session for students D, E, and F, respectively). For the student whose problem behavior was multiply controlled, the impact of task choice was evaluated by alternating attention and escape conditions within a multielement design. In the attention condition, the student selected a task and problem behavior resulted in access to 5 s of attention. During the escape condition, the student was allowed to choose a task and the occurrence of problem behavior resulted in a 10-s break. When offered task choice in the escape condition, there were significantly lower rates of problem behavior ($M = 2\%$) than when task choice was offered in the attention condition ($M = 72\%$). Overall, the results indicate that individuals who exhibit escape-maintained problem behaviors may benefit from choice-making interventions.
Taken together, the current empirical knowledge base suggests that there is more than one plausible explanation regarding the principles that underlie the effects of choice making on students’ responding. One such explanation is that the provision of choice allows students to select the more preferred task and avoid aversive tasks, minimizing the MO that made escape from the instructional environment reinforcing in the first place (Dunlap et al., 1991; 1994; Jolivette, Wehby, Canale, & Massey, 2001; Powell & Nelson, 1997; Romaniuk et al., 2002). A second plausible explanation is that the opportunity to choose increases the reinforcing value of a task, thus reducing the likelihood of escape-maintained problem behavior (Killu et al., 1999; Umbreit & Blair, 1996; Vaughn & Horner, 1997). Both explanations speak to the preventative function of choice-making interventions. That is, the provision of choice alters some aversive feature of the instructional environment, reducing the probability of the occurrence of escape-maintained problem behaviors. In doing so, choice-making interventions may be an optimal treatment for students whose problem behaviors are escape-maintained. However, a review of the literature revealed no studies that have compared choice-making interventions to other treatments that have been shown to be effective with escape-motivated behavior. It therefore remains unclear whether choice is as effective as other strategies like DNRA or DRA.

Another limitation within the choice-making literature is the lack of attention given to academic responding. That is, while the effectiveness of choice-making interventions on students’ task engagement, work completion, and problem behavior is well documented within the literature, Morgan (2006) reviewed the choice-making literature and reported that only a limited number of studies have evaluated the effects of
choice making on students’ academic responding. In one such investigation, Cosden, Gannon, and Haring (1995) conducted a two-phase study to examine the effects of choice of task and reinforcer on the assignment accuracy of three students with severe behavior problems. In the first phase of the study, an alternating-treatment design was used to compare the impact of three interventions conditions: (1) teacher control of task assignment and reinforcer, (2) student control of reinforcer, and (3) student control of task assignment and reinforcer. In the teacher-control condition, the teacher selected the academic task and reinforcer. In contrast, during the student-control of task assignment and reinforcer condition, the teacher presented 10 reinforcer cards and 10 task cards and allowed the student to choose one of each. During the student-control of reinforcer condition, the teacher selected the academic task and presented 10 reinforcer cards and allowed the student to choose one. All three students demonstrated the highest levels of assignment accuracy when they selected the academic task and reinforcer, followed by the condition in which they selected the reinforcer. During Phase 2 of the study, a fourth intervention condition was added. In this condition, the student controlled the choice of academic task. This phase also included a reinforcement contingency that required the students to achieve 85% accuracy in order to receive the reinforcer. Similar to phase 1, the highest levels of assignment accuracy were observed during the student-control-of-task-and-reinforcer condition, with assignment accuracy as much as four times higher than when the teacher selected the task and reinforcer. Additionally, higher levels of assignment accuracy were typically observed when the student selected either the task or reinforcer than when the teacher selected both components.
Ramsey, Jolivette, Patterson, and Kennedy (2010) provided additional evidence in support of the use of choice for improving academic responding when they examined whether providing students with emotional and behavioral disorders (EBD) the opportunity to make choices regarding the order of task completion would subsequently impact their accuracy, on-task behavior, and task completion. During independent work time in math and language arts classes, teachers presented the academic tasks to students and either allowed them to choose the order of completion (choice condition) or the teacher selected the order in which the assignments needed to be completed (no-choice condition). An A/B/A/B design was used to compare the choice and no-choice conditions. For four out of the five students, higher percentages of accuracy, time on-task, and task completion were exhibited when explicit choices were provided. Similarly, Moes (1998) demonstrated that when students with Autism were allowed to choose the order of task completion as well as the stimulus materials (e.g., specific type of pens, glue, scissors) that would be used during homework activities, there were noticeable improvements in the rate and accuracy of the student’s responses with concomitant reductions in their off-task and disruptive behavior. The results of these studies are very encouraging and suggest that choice is a viable treatment option for improving academic responding.

Daly, Garbcacz, Olson, Persampieri, and Ni (2006) expanded the application of choice to oral reading fluency. In this investigation, the researchers used a multiple-probe-across-tasks (passages) design to examine the effects of student choice making on oral reading fluency. Two middle-school students with behavior disorders were given a choice of whether they would be instructed, and, if so, the amount of time they would
receive instruction, as well as the instructional strategies that would be implemented. Prior to the first treatment session, an experimenter described each instructional strategy – listening passage preview, repeated reading, error correction, and performance feedback – and had the students practice each one using a novel passage. During the instructional sessions, the students were informed that they would receive a reward for meeting a pre-determined goal on the criterion passage. Positive reinforcement was used to try to motivate students to choose to be instructed rather than not be instructed. The choice to be instructed was significant because it involved increased response effort on the part of the participants who were free to not be instructed. Accordingly, before the student read the criterion passage, the experimenter offered the student the choice of whether or not to receive instruction. If the student chose to receive instruction, the student then selected the instructional strategies to be used. The experimenter then delivered the student-chosen instructional strategies before having the student read the criterion passage. The students were able to elect to stop being instructed at any time or they could receive a maximum of 10 min of instruction in the instructional passage. Both students consistently chose to receive instruction. Oral reading fluency rates increased in the criterion passages when student-chosen instruction was introduced. These findings contribute to the small research base demonstrating the effectiveness of choice-making interventions for improving academic responding. In light of these positive findings, future research is warranted to examine if the effects of choice-making interventions extend to other academic areas such as math computation fluency. The findings of this study also provide preliminary evidence for the effectiveness of combining choice and programmed reinforcement to improve students’ academic responding. However, since
the authors did not isolate the independent effects of choice and programmed reinforcement, future studies should examine this, especially in relation to other evidence-based interventions.

**Purpose of the Present Study**

Over half of our nation’s students are performing below grade level in the content area of mathematics and will continue to lag behind their same-aged peers in the absence of effective interventions (NCES, 2011). For some of these students, their low academic performance in mathematics is due more to motivational issues (reinforcement and motivating operations) than to skill factors (i.e., poor stimulus control). As a result, they engage in undesirable behavior (e.g., aggression, destruction of property, SIB, or disruptive behaviors) that allows them to escape or avoid math tasks which, consequently, hinders their performance (Gresham, 2007). When this situation is present, interventions to enhance student motivation may be more appropriate (Daly et al., 2010).

Consequence-based interventions like DRA and DNRA have been shown to be effective for decreasing students’ undesirable behavior (e.g., self-injurious or disruptive behaviors, non-compliance, aggression) maintained by escape from instructional demands and for increasing alternative, desirable behavior (e.g., task engagement, work completion, compliance) because they alter the reinforcement contingencies such that it is easier for a student to obtain reinforcement for engaging in desirable behavior than for undesirable behavior (Carr et al., 1980; Geiger et al., 2010; Golonka et al., 2000; Marcus & Vollmer, 1995; Piazza et al., 1996; Vollmer et al., 1999; Warzak et al., 1987). There is also substantial evidence demonstrating that the antecedent-based intervention of choice of consequences and of tasks decreases problem behavior (e.g., disruptive, self-injurious,
and off-task behaviors) and increases desired behavior (e.g., task engagement, work completion, assignment accuracy, oral reading fluency) of students with and without disabilities. It would appear that choice may be effective because it provides access to a higher preference condition when the person is faced with a choice, even when the choice is between two low-preference tasks. Access to the higher preference condition may function to reduce the aversiveness of the stimulus situation, thereby decreasing the reinforcing value of escape-maintained behavior (e.g., Cosden et al., 1995; Daly et al., 2006; Dyer et al., 1990; Dunlap et al., 1991; 1994; Kern et al., 1998; 2001; Moes, 1998; Morgan, 2006; Ramsey et al., 2010; Stenhoff et al., 2008; Umbreit & Blair, 1996; Vaughn & Horner, 1997). Despite the considerable research base for choice-making interventions, to date the effects of task choice on students’ math computation fluency has not been examined. Additionally, few studies have explored the relationship between task choice and the underlying function of an individual’s behavior (Romaniuk & Miltenberger, 2001). Moreover, it is unclear how well the antecedent-intervention of task choice compares to powerful consequence-based treatments like DRA and DNRA.

Studies have compared the effects of DNRA and DRA and suggest that in some cases individuals may prefer the positive reinforcer over the functional reinforcer (i.e. escape from instructional stimuli) or that the presence of a high-preference positive reinforcer acts as an AO, momentarily decreasing the reinforcing value of escape (Smith, 2011). The results also suggest that interventions using DRA may be more effective than DNRA procedures in improving desirable behaviors and decreasing escape-maintained problem behaviors. However, further research is warranted to substantiate this claim.

Also, the majority of the comparative studies targeted task compliance. Thus, it would be
worthwhile to determine if similar results would be obtained if academic responding (e.g., math computation fluency) was the target behavior. Furthermore, it remains unclear how effective choice is when combined with DRA. Daly et al. (2006) is one of the few investigations to use DRA and choice; however, the authors failed to isolate the effects of the different variables or to compare the combined treatment to other interventions. Therefore, further research is warranted to examine the independent and combined effects of choice and DRA relative to DNRA.

In light of the aforementioned limitations and gaps in the research literature, the purpose of the current investigation was twofold. The first purpose was to examine the effects of task choice on the math computation fluency of students whose low rates of responding was due to escape. The second purpose of the study was to compare antecedent (choice) and consequence-based (DRA and DNRA) strategies to determine which treatments or combination of treatments produced the strongest improvements in math computation fluency with elementary-school children whose responding was controlled by a negative reinforcement contingency. When effective, antecedent interventions prevent problem behavior from occurring in the first place. This might be a benefit relative to consequence-based treatments which may allow behavior to occur more often as discriminations take place over time (both reinforcement and extinction effects). On the other hand, it is primarily consequences that change behavior (antecedents control behavior through their association with consequences), and therefore consequence-based treatments might be naturally more potent than antecedent interventions like choice.
Corresponding to the purpose of the current investigation, four research questions were examined. First, since few studies to date have actually examined the effects of choice on academic responding, this study sought to contribute to this research literature. Therefore, one research question that it sought to answer was, can choice effects be replicated when applied to math computation fluency for students whose low rates of math computation fluency were due to escape? In light of the considerable research base demonstrating the positive effects of choice making interventions on a variety of target behaviors (e.g., task engagement, work completion, assignment accuracy, oral reading fluency), it was hypothesized that task choice would result in higher levels of math computation fluency relative to a control condition.

Second, to date, no studies have compared the antecedent-intervention of task choice to consequence-based treatments (i.e., DRA and DNRA) to determine which produces the optimal treatment outcomes. In order to address this limitation, a second research question that this study sought to answer was, how well does task choice improve students’ math computation fluency when compared to consequence-based strategies? Research supports the effectiveness of choice for students displaying escape-motivated behavior, and its ability to influence the motivating conditions supporting escape-motivated behavior would suggest that it is functionally appropriate under these conditions. Given this preventative function, it was hypothesized that the antecedent intervention of task choice would produce equal effects to consequence-based treatments (DRA and DNRA) in improving students’ math computation fluency.

Third, evidence supporting the effectiveness of combining choice and DRA to improve students’ oral reading fluency (Daly et al., 2006) suggests that a combined
treatment might be effective as well. Thus, a third research question that this study sought to address was, can a combined treatment of task choice plus DRA produce larger improvements in math computation fluency than the single-component treatments (task choice, DRA, DNRA)? Given the potency of task choice or DRA in isolation, it would appear that combining them may produce superior effects to either one by itself. It was therefore hypothesized that the combination of task choice and DRA would result in higher levels of math computation fluency than the single-component treatments (task choice, DRA, DNRA).

Lastly, although studies have compared the effects of DRA and DNRA, the majority have targeted task compliance. In order to determine if similar results would be obtained if academic responding (i.e., math computation fluency) were the target behavior, a fourth research question was, how do consequence-based treatments (i.e., DNRA and DRA) compare to one another in improving the math computation fluency of students whose low academic performance was escape-maintained? Since comparative studies have suggested that DRA may result in greater behavior change than DNRA for escape-maintained behavior, it was hypothesized that DRA would produce higher rates of math computation fluency than DNRA.

In order to answer each research question, an experimental analysis of five conditions was conducted to examine the effects of these treatments on the math computation fluency of elementary-aged students who displayed escape-motivated behavior. It contained five conditions: Baseline, Task Choice, DRA, Task Choice+DRA, and DNRA. First, a functional analysis was conducted to identify elementary-school students whose academic responding was under a negative-reinforcement contingency.
Next, a preference assessment was administered to each student to identify potentially effective reinforcers in the form of permissible school activities. These high-preference activities were used during the DRA and Task Choice+DRA conditions. Finally, an experimental analysis was conducted to answer the research questions. After a Baseline phase, four treatments were rapidly alternated with counterbalancing within a multielement design. The findings of this study shed light on the effectiveness of choice relative to reinforcement procedures, whether there was additional benefit to combining treatments, and which type of reinforcement procedures (DRA or DNRA) were more effective.
CHAPTER 2

Method

Participants

The participants in the study included four students (one male and three females) enrolled at an urban, public elementary school located in a Midwestern school district. The female participants (Hillary, Jamie, and Shannon) were third-grade students and the male participant (Matt) was a first-grade student. (All names provided are pseudonyms.) One of the students was African-American and three were Middle Eastern. None of the students were receiving special education services. However, two of the students were identified as English Language Learners and received services in this area. Approval for this study was obtained from the Human Subjects Institutional Review Board (IRB #13771).

The first step of the recruitment process involved meeting with the school’s administrators to gain their approval to conduct the study. Following their approval, the researcher met with interested teachers to describe the study, review the consent form, and answer questions. These teachers then identified students in their classrooms who exhibited poor math computation fluency and would benefit from participation in the study. The teachers and primary caregivers of the students nominated for participation were asked to provide consent and student assent was also obtained.

Setting

All sessions were conducted in a quiet hallway at the public elementary school. Students met with the experimenters individually and sat at an appropriately sized desk with two chairs. The author, four trained school psychology doctoral students, and two
trained undergraduate students were responsible for implementation of the functional-analysis and experimental-analysis procedures as well as the screening and stimulus-preference sessions.

**Materials**

**Reinforcement.** Items used for programmed reinforcement included activities such as cross-word puzzles, games (e.g., UNO®), and journaling. The activities were written on separate index cards (3 in by 5 in).

**Worksheets.** Math worksheets and corresponding answer sheets were used during all phases of the study and were created from the web site interventioncentral.org (Wright, 2006). In the screening phase, each math worksheet contained approximately 72 randomly generated problems, targeted a single skill (e.g., one-digit-by-one-digit addition problems, two-digit-by-two-digit, no regrouping addition problems), and had a corresponding answer sheet (see Appendix A). Math worksheets and corresponding answer sheets were created for every computation skill previously taught to the students (based on teacher report). During the functional-analysis and experimental-analysis phases, math worksheets contained approximately 12 randomly generated problems, targeted a single skill (e.g., one-digit by one-digit addition problems), and had a corresponding answer sheet (see Appendix B). In the experimental-analysis phase, any condition that involved choice (i.e., the Task-Choice condition and Task-Choice+DRA condition) contained three different kinds of math worksheets – Form A, B, and C. Form A was identical to the math worksheets used during the functional-analysis and experimental-analysis sessions. Form A contained two rows with six math problems in each row (see Appendix C). Form B differed from Forms A and C in terms of how the
math problems were aligned on the paper and the inclusion of clip art (e.g., superhero, cat, race car). Form B contained six rows with two math problems in each row and clip art on the upper left corner and lower right corner (see Appendix D). Similarly, form C differed from Forms A and B in terms of how the math problems were aligned on the paper and the insertion of clip art (i.e., a star giving a thumbs up). Form C contained three rows with four math problems in each row and a clip art design intermittently included throughout the worksheet (see Appendix E). The types of items on each form (A, B, and C) were equivalent, making them equal in difficulty. The only difference between them was the arrangement of problems on the page and the presence or absence of different types of clip art. All forms had corresponding answer sheets.

**Measures**

**Math computation fluency.** The primary dependent variable during the study was math computation fluency. In the screening phase, the correct number of digits per 2 min was calculated for each math worksheet. The experimenter scored a digit as correct if the correct digit was written in the appropriate column and place. The experimenter referred to the appropriate answer sheet to determine if a digit was correct. Then the experimenter counted all of the correctly completed digits to obtain each student’s correct number of digits per 2 min for each math worksheet. During the functional-analysis and experimental-analysis sessions, the rate of correctly completed digits per min was calculated by first dividing the amount of time in seconds the student worked on math worksheets from the number of correct digits completed during a session. The result was multiplied by 60 to determine rate per min.

**Stimulus-Preference Assessment**
**Item selection.** Prior to the start of the experiment, each student’s teacher was asked to review common school activities that can serve as potential reinforcers and select eight that she believed would be appropriate for the school setting and potentially motivating for the student (see Appendix F). These eight activities were then presented during the three trials of the multiple-stimulus without replacement (MSWO) assessment.

**Response definition and measurement.** A student’s selection response was recorded when he or she pointed to or picked up one of the activity cards or verbally indicated a selection. The student was instructed to select an activity card, and the experimenter sat quietly and awaited a selection. If the student made contact with more than one activity card, the experimenter told the student to choose one activity card only. If the student failed to make a selection, the experimenter again prompted the student to choose an activity which he or she would be willing to do for completing math problems. The student’s selection was then recorded.

**Procedure.** Each student received three identical trials of the MSWO assessment (see Appendix G). Each trial was conducted on a different day. In the beginning of a trial, the experimenter randomly arranged eight activity cards in a horizontal line in front of the student. The experimenter read the activity on each card and had the student read it back to make certain that he or she understood what each card stood for and what each item was. The experimenter answered any questions the student had about the activities. The experimenter then asked the student to choose an activity which he or she would be willing to do for completing math problems. When the student selected an activity, the activity card was removed from the table. The remaining activity cards were re-arranged by shifting all the cards to the right of the chosen card one place to the left to fill in the
gap. Next the card furthest to the experimenter’s left was moved to the place furthest to his or her right. The array of cards was then re-centered in front of the student. This procedure continued until one activity card remained on the table. The experimenter ranked activities 1-8, depending on the order in which they were chosen (e.g., the first chosen activity card received a ranking of 1; the second chosen activity card was ranked 2, etc.). The experimenter marked the MSWO recording sheet (see Appendix H) to appropriately reflect the order in which each item was selected.

After a student received three trials of the MSWO assessment, the median score for each activity card across the three trials was selected as the score for that item. These median numbers were reversed scored such that the lowest median score (e.g., “1”) received the highest score of “8” and the next lowest median score (e.g., “2”) received the next highest score of “7” and so on. If there was a tie (e.g., top two items received median scores of “2”), the experimenter gave the mean of the two proximal rankings (e.g., mean of “8” and “7” is “7.5”) and did not assign a whole number score for the two most proximal scores (e.g., “8” & “7”). This information was used to determine a student’s preference level for an activity whereby the activities with the two highest median rankings (e.g., “8” & “7”) were identified as high-preference activities for that student, the activities with the two lowest median rankings (e.g., “1” & “2”) represented the low-preference activities for that student, and the remaining items were identified as medium-preference activities for that student. The results for each student are presented in Figures 1-4.
**Functional Analysis**

Functional analyses were conducted using a multielement design to experimentally examine the impact of escape from academic demands and social attention on each student’s math computation fluency (i.e., replacement behavior). These functions were tested because they are common sources of reinforcement for problem behaviors in the classroom (Vollmer & Northup, 1996). Additionally, a control condition was implemented to allow for comparisons across conditions. Student academic responding was reinforced instead of problem behaviors to provide a direct link to the development of effective function-based interventions. The order in which the conditions were implemented was randomized in a balanced fashion (Kazdin, 2011). In other words, all conditions were administered once in random order. Then, all conditions were re-administered in random order, and the process was repeated until student responding stabilized and there was clear differentiation across conditions. Balancing in this fashion assured both randomization and equal exposure to all conditions by the participants. The experimenter implemented one condition (social attention, escape, control) per session and each session lasted 10 min. The experimenter met with the students individually and worked in a quiet hallway at the school. A general description of each condition appears below.

**Social attention condition.** During the social attention condition (see Appendix I), the experimenter placed a stack of math worksheets on the desk so they were readily accessible to the student and the experimenter but were not directly in front of the student. Next, the experimenter asked the student if the math worksheets were close enough for him or her to reach them. If the student said, “no,” the experimenter
repositioned the math worksheets and asked the question again. Once the math worksheets were appropriately positioned on the desk, the experimenter notified the student that he or she had 10 min to work on the math worksheets and should try to complete as many problems as he or she could. The experimenter further explained that while the student worked on the math problems, the experimenter would be watching and tell the student if he or she was doing a good job. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter supervised the student’s work completion and provided positive social attention (e.g., “Way to go!,” “Good job!,” etc.) on a FR 4 schedule. If the student stopped working on math problems at any time before the 10 min was up, the experimenter prompted the student to continue working on the math problems and to do the next problem. At the end of the 10-min session, the experimenter instructed the student to stop working and provided the student with specific praise (e.g., “Awesome job completing all of these math problems!”). After providing the student with specific praise, the experimenter collected the math worksheets and took the student to his or her homeroom classroom. Then the experimenter referred to the appropriate answer sheets and counted the total number of correctly completed digits and recorded this number as well as the date of the session on the functional-analysis recording sheet (see Appendix J).

**Escape condition.** In the escape condition (see Appendix K), the experimenter placed a stack of math worksheets on the desk so they were readily accessible to the student and the experimenter but were not directly in front of the student. Next, the experimenter asked the student if the math worksheets were close enough for him or her
to reach them. If the student said, “no,” the experimenter repositioned the math worksheets and asked the question again. Once the math worksheets were appropriately positioned on the desk, the experimenter notified the student that he or she would have 10 min to work on the math worksheets and should try to complete as many problems as he or she could. The experimenter further explained that each time the student finished a math worksheet, the experimenter would give the student a brief break. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter supervised the student’s work completion. If the student stopped working on math problems at any time before completing a math worksheet, the experimenter prompted the student to continue working on the math problems and to do the next problem. Every time the student completed 12 math problems (i.e., one math worksheet), the experimenter told the student that he or she could take a break. The experimenter then picked up the math worksheets, placed a check mark in a box to indicate the student was receiving a break, and allowed the student to sit quietly for 30 s. During the 30-s break, the experimenter did not provide any social attention to the student and sat quietly and worked on another activity. After the 30-s break, the experimenter placed a new worksheet in front of the student, provided there was time remaining in the condition, and prompted the student to continue working on the math problems. At the end of the 10-min session, the experimenter instructed the student to stop working, collected the math worksheets, and returned the student to his or her homeroom classroom. Then the experimenter referred to the appropriate answer sheets and counted the total number of correctly completed digits and recorded this
number on the functional-analysis recording sheet. The experimenter also recorded the number of breaks the student received and the date of the session.

**Control condition.** During the control condition (see Appendix L), the experimenter placed a stack of math worksheets on the desk so they were readily accessible to the student and the experimenter but were not directly in front of the student. Next, the experimenter asked the student if the math worksheets were close enough for him or her to reach them. If the student said, “no,” the experimenter repositioned the math worksheets and asked the question again. Once the math worksheets were appropriately positioned on the desk, the experimenter notified the student that he or she had 10 min to work on the math worksheets and could do as much or as little work as he or she would like but that the student must remain quiet during the session. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. If the student asked for help or sought the experimenter’s attention, the experimenter responded by saying, “Just do your best.” At the end of the 10-min session, the experimenter instructed the student to stop working, collected the math worksheets, and returned the student to his or her homeroom classroom. Then the experimenter referred to the appropriate answer sheets and counted the total number of correctly completed digits and recorded this number as well as the session date on the functional-analysis recording sheet.

The students’ academic responding under each functional analysis condition was graphed and analyzed visually to select the condition that produced visibly higher levels of academic responding than the other conditions. Students who demonstrated visibly
higher levels of academic responding during the escape condition compared to the social attention and control conditions were chosen for participation in this study.

**Experimental-Analysis Conditions**

**Control.** The control condition was identical to the control condition in the functional-analysis phase with the exception that the session lasted for 5 min (see Appendix M). Control sessions were implemented as a baseline (before treatment) until student responding stabilized. The control condition was implemented to serve as the standard against which the intervention conditions were compared to determine the magnitude of each intervention’s effect.

**Task choice.** During the Task-Choice condition (see Appendix N), the experimenter placed three different stacks of math worksheets (i.e., Forms A, B, and C) on the desk. One stack of math worksheets was positioned to the left of the student, the second stack of math worksheets to the right of the student, and a third stack of math worksheets directly in front of the student. Placement to the left, right, or before the student was randomized across sessions to ensure that the position of the math worksheets did not influence the student’s selection. Each stack of math worksheets was an equal distance from the student, readily accessible to him or her and the experimenter. The experimenter asked the student if the math worksheets were close enough for him or her to reach them. If the student said, “no,” the experimenter repositioned the math worksheets and asked the question again. Once the math worksheets were appropriately positioned on the desk, the experimenter asked the student which stack of math worksheets (i.e., Form A, B, or C) he or she would like to work on today. After the student pointed to or verbally indicated his or her preference, the experimenter verified
the choice by picking up the stack of math worksheets and asking the student if he or she wanted to work on that stack of math worksheets. If the student said, “no,” the experimenter repositioned both stacks of math worksheets and asked the question again (i.e., “Which stack of math worksheets do you want to work on today?”). Once the student’s selection was verified, the experimenter removed from the desk the stack of math worksheets the student did not choose. The experimenter then notified the student that he or she had 5 min to work on the math worksheets and should try to complete as many problems as he or she could. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. If the student asked for help or sought the experimenter’s attention the experimenter responded by saying, “Just do your best.” At the end of the 5-min session, the experimenter instructed the student to stop working, collected the math worksheets, and took the student to his or her homeroom classroom. Then the experimenter referred to the appropriate answer sheets and counted the total number of correctly completed digits and recorded this number as well as the session date on the experimental-analysis recording sheet.

**Differential reinforcement of alternative behavior.** Criteria for earning access to the activities during the experimental-analysis conditions was established based on the correctly completed digits obtained by each student during baseline sessions. Specifically, each student’s average number of correctly completed digits during baseline sessions was calculated. Reinforcement criteria were selected within a range from +1.5 to +2.0 SD above each student’s baseline average. For all students, the criterion for reinforcement varied randomly across sessions in which reinforcement was available.
That is, prior to the start of the intervention phase, the experimenter generated a list of random numbers within each student’s range of 1.5 to 2 SD above the baseline average. The experimenter then wrote these numbers on note cards. Prior to DRA sessions, the experimenter randomly selected one performance criterion number for that session and placed it in a sealed envelope. The experimenter also randomly selected an index card representing one high-preference activity based on the MSWO results for that student prior to the session.

During the DRA session (see Appendix P), the experimenter informed the student that he or she could earn a reward for doing math problems in the session. The experimenter further explained that at the end of the session, the experimenter would open the envelope and take out a note card with a number on it. If the student correctly completed an equal or greater number of digits than the number on the note card, the student earned a reward. The experimenter then displayed the envelope to the student and placed the appropriate activity card (i.e., the reward) at the top of the desk so that the student knew the activity that could be earned during the session. After placing the activity card at the top of the desk, the experimenter then placed a stack of math worksheets on the desk so they were readily accessible to the student and the experimenter but were not directly in front of the student or covering up the activity card. Next, the experimenter asked the student if the math worksheets were close enough for him or her to reach them. If the student said, “no,” the experimenter repositioned the math worksheets and asked the question again. Once the math worksheets were appropriately positioned on the desk, the experimenter notified the student that he or she had 5 min to work on the math worksheets and should try to complete as many problems
as he or she could. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. If the student asked for help or sought the experimenter’s attention the experimenter responded by saying, “Just do your best.”

At the end of the 5-min session, the experimenter instructed the student to stop working. The experimenter then collected the math worksheets, referred to the appropriate answer sheets and counted the number of correctly completed digits, and recorded this number as well as the session date on the experimental-analysis recording sheet. Next, the experimenter reached into the envelope and picked out a note card. The experimenter then notified the student of the goal for the session (according to the number on the card), and told the student whether he or she met the goal or not. If the student completed an equal or greater number of digits than the number on the note card, the experimenter told the student that he or she met the goal and earned the reward. The experimenter provided praise (e.g., say, “Good job”) to the student and told the student that he or she had 10 min of access to the reward. The experimenter then delivered the reward and set a timer for 10 min. At the end of the 10 min, the experimenter returned the student to his or her homeroom classroom. If the student did not complete an equal or greater number of digits than the number on the note card, the experimenter told the student that he or she did not meet the goal for the session and that an opportunity to earn the reward would be provided in a future session. Following this performance feedback, the experimenter returned the student to his or her homeroom classroom.

**Task choice plus differential reinforcement of alternative behavior.** In the Task-Choice+DRA condition (see Appendix Q), the experimenter informed the student
that he or she could earn a reward for doing math problems in the session. The experimenter further explained that at the end of the session, the experimenter would open the envelope and take out a note card with a number on it. If the student correctly completed an equal or greater number of digits than the number on the note card, the student would earn a reward. The experimenter then displayed the envelope to the student and placed the appropriate activity card (i.e., the reward) at the top of the desk so that the student knew the activity that could be earned during the session. After placing the activity card at the top of the desk, the experimenter then placed three different stacks of math worksheets (i.e., Forms A, B, and C) on the desk. One stack of math worksheets was positioned to the left of the student, the second stack of math worksheets to the right of the student, and a third stack of math worksheets was placed directly in front of the student. Placement to the left, right, or before the student was randomized across sessions to ensure that the position of the math worksheets did not influence the student’s selection. Each stack of math worksheets was an equal distance from the student, readily accessible to him or her and the experimenter. The experimenter asked the student if the math worksheets were close enough for him or her to reach them. If the student said, “no,” the experimenter repositioned the math worksheets and asked the question again.

Once the math worksheets were appropriately positioned on the desk, the experimenter asked the student which stack of math worksheets (i.e., Form A, B, or C) he or she would like to work on today. After the student pointed to or verbally indicated his or her preference, the experimenter verified it by picking up the stack of math worksheets and asking the student if he or she wanted to work on that stack of math worksheets. If the student said, “no,” the experimenter repositioned both stacks of math worksheets and
asked the question again (i.e., “Which stack of math worksheets do you want to work on today?”). Once the student’s selection was verified, the experimenter removed from the desk the stack of math worksheets the student did not choose. The experimenter then notified the student that he or she had 5 min to work on the math worksheets and should try to complete as many problems as he or she could. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. If the student asked for help or sought the experimenter’s attention the experimenter responded by saying, “Just do your best.”

At the end of the 5-min session, the experimenter told the student that the time was up and that she would determine how many digits the student got correct. The experimenter then collected the math worksheets, referred to the appropriate answer sheets and counted the number of correctly completed digits, and recorded this number as well as the session date on the experimental-analysis recording sheet. Next, the experimenter reached into the envelope and picked out a note card. The experimenter then notified the student of the goal for the session (according to the number on the card), and told the student whether he or she met the goal or not. If the student completed an equal or greater number of digits than the number on the note card, the experimenter told the student that he or she met the goal and earned the reward. The experimenter provided praise (e.g., say “Good job”) to the student and told the student that he or she had 10 min of access to the reward. The experimenter then delivered the reward and set a timer for 10 min. At the end of the 10 min, the experimenter returned the student to his or her homeroom classroom. If the student did not complete an equal or greater number of digits
than the number on the note card, the experimenter told the student that he or she did not meet the goal for the session and that an opportunity to earn the reward would be provided in a future session. Following this performance feedback, the experimenter returned the student to his or her homeroom classroom.

**Differential negative reinforcement of alternative behavior.** The differential-negative-reinforcement-of-alternative-behavior condition was identical to the contingent-escape condition in the functional-analysis phase with the exception that the session lasted for 5 min (see Appendix R).

**Experimental Design and Procedures**

A multielement design was used to examine the effect of Task Choice, DRA, Task Choice+DRA, and DNRA on the students’ math computation fluency. An initial Baseline phase was followed by the intervention phase. The order in which the interventions were implemented was counterbalanced within students until student responding stabilized under the separate conditions. For the multielement design, experimental control is demonstrated when there is clear differentiation in responding across the intervention conditions, as manifested by clearly discriminable data series between conditions.

**Screening phase.** Before beginning the screening phase, the experimenter asked the students’ teachers to identify math skills the students had previously learned. Based on this information, math worksheets were created for every skill the teachers identified. Each skill was assessed using a 2 min probe. During screening sessions, the experimenter gave the student a pencil and a math worksheet, placing it face down. The experimenter held up a sample math worksheet and informed the student that he or she was going to do
some math problems today but first the student had to write his or her first name and date at the top of the paper. Once the student wrote his or her name on the top of the worksheet, the experimenter informed the student that he or she had 2 min to work on the math worksheet (see Appendix S). The experimenter further explained that if the student could not answer a problem, he or she should skip it and go on to the next problem. Following this explanation, the experimenter instructed the student to begin working. As the student worked on the math problems, the experimenter sat quietly and worked on another activity. At the end of the 2 min-session, the experimenter told the student that the time was up and collected the math worksheet. The experimenter continued administering math worksheets using the same procedures outlined previously until all of the skills were assessed.

The experimenter first presented the math worksheet that contained the most difficult problems and continued to administer math worksheets in accordance with their difficulty level (i.e., worksheets that contained harder math problems were administered ahead of worksheets that contained easier math problems). After all of the screening math worksheets were administered or if the student displayed fatigue, the experimenter returned the student to his or her classroom. Multiple sessions were necessary with three of the students. The correct number of digits per 2 min for each math worksheet was recorded on a screening recording sheet (see Appendix T). The results were compared to local or national benchmark norms to determine which scores were below the 50th percentile. The easiest skill (i.e., lowest skill in the curriculum) below the 50th percentile was selected as the target skill for the participant in this study.
**Experimental-analysis phase.** In the experimental-analysis phase, following baseline, all four intervention conditions were presented to each student across several sessions in a randomized, balanced sequence. Prior to the start of the experimental-analysis phase, the experimenter ordered the intervention conditions and balanced the order within students, as noted previously. Conditions were administered an equal number of times until conditions stabilized within series. Only one intervention condition was implemented per session. During each session, the experimenter met with the students individually for 10 to 25 min, depending on the condition, and worked in a quiet hallway at the school.

**Interobserver Agreement**

For the purposes of obtaining interobserver agreement (IOA), the experimenter and an independent observer were present during all three trials of the stimulus-preference assessment to simultaneously record each student’s selection responses. Agreements were defined as both observers recording the same selection response or the absence of a selection response. To calculate IOA, the recordings of the two observers were compared by dividing agreements by the number of agreements plus disagreements and multiplying the result by 100%. The mean IOA for students’ selection responses was 100%. During each session of the study, the experimenter scored the math worksheets. Two independent observers scored a random sample of 30% of the completed math worksheets. Agreement for math digits was defined as both observers recording a digit as correct or incorrect. A disagreement for math digits was defined as any discrepancy between observers in relation to the same math digit (e.g., one observer scored a digit in the ones column for a particular problem as correct whereas the other observer scored
that same digit as incorrect). IOA was calculated by dividing agreements by the number of agreements plus disagreements and multiplying the result by 100% to arrive at a percentage. The mean IOA for correct number of digits was 100.

**Treatment Integrity**

In order to evaluate whether the procedures were carried out as designed, all sessions were audio-recorded. Two independent observers listened to a random sample of 30% of the recorded stimulus-preference assessment sessions, functional-analysis, and experimental-analysis sessions and recorded whether steps were implemented correctly using treatment protocols that outlined every step of the session (see Appendices G, I, K, L, M, N, P, Q, and R). To calculate treatment integrity (TI), total number of steps implemented correctly was divided by the total number of steps according to the protocol. The result was multiplied by 100 to arrive at a percentage. The mean TI for the study was 99.84% (range, 92% to 100%).

**Data Analysis**

**Visual inspection.** The primary data analysis method was visual inspection of graphed data. Specifically, graphed data was examined for changes in level (i.e., observable increase or decrease in student responding upon implementation of a specific intervention), trend (i.e., noticeable increase or decrease in student responding over time), and variability (i.e., the stability of student responding over time) within and across baseline/control and intervention conditions (Kazdin, 2011). In a multielement design, experimental control is evidenced by visible differentiation in responding across experimental conditions (Steege & Watson, 2009).

**Structured criteria for visual inspection.** As an additional data-analytic method,
differences between conditions were examined using the conservative dual-criteria method (CDC; Fisher, Kelley, & Lomas, 2003). This method was first used to examine the significance of each intervention’s effect compared to baseline by determining if a sufficient number of intervention data points exceeded the baseline mean and trend lines based on the binomial distribution. The CDC method was then used to compare each treatment condition (e.g., Task Choice) to another treatment condition (e.g., DRA and DNRA) according to the research questions being addressed. The validity of the CDC method has been established by research indicating its superiority for detecting treatment effects compared to other methods such as the general linear model and other statistical evaluation methods (Fisher et al., 2003).

**Effect sizes.** As a supplement to visual analysis and the CDC method, standard mean-difference effect sizes were calculated for each intervention (Task Choice, DRA, Task Choice+DRA, and DNRA) to determine the magnitude of behavior change relative to baseline (Busk & Serlin, 1992). To obtain an effect size for a given intervention, the difference between the baseline and intervention means for an individual student was divided by the standard deviation of baseline. This effect size represented how far (in standard deviation units) the average intervention data point was below (negative effect) or above (positive effect) baseline. The effect sizes were interpreted according to Cohen’s criteria (1988) of small (.2), medium (.5), and large (.8) effects.
CHAPTER 3

Results

Functional Analysis

The functional analysis was intended to identify participants whose academic responding was under a negative reinforcement contingency. Figures 5 through 8 display the participant results across reinforcement conditions (i.e., escape, social attention, and control). The functional analyses reveal differentiated patterns of responding for all four participants, with escape producing higher rates of correct digits per min than the attention and control conditions.

Hillary. Figure 5 displays Hillary’s functional analysis results. Visual inspection of Hillary’s rate of correct digits per min reveals a differentiated pattern of responding across conditions. An increasing trend is evident in the escape condition, whereas a stable if not slightly decreasing trend is visible in the social attention condition. The control condition produced stable levels of responding after an initially low data point (Session 1), results that were comparable with the social attention condition. Summary statistics appear in Table 1. The escape condition produced the highest mean rate of correct digits per min (M = 25.21, SD = 3.23) compared to the social attention (M = 21.62, SD = 1.64) and control (M = 20.54, SD = 2.29) conditions.

Jamie. Jamie’s functional analysis results appear in Figure 6. Jamie’s rate of correct digits per min shows a differentiated pattern of responding across conditions. Conditions are differentiated during the first two sessions, with the social attention condition producing the highest levels of responding followed by escape and then control. Results converge and overlap during the third session, after which a
differentiated pattern again emerges for the remaining three sessions. The new pattern of differentiation favored the escape condition over the social attention and control conditions. As with Hillary, it appears that it took several sessions for Jamie to discriminate the reinforcement conditions. Summary statistics appear in Table 1. The escape condition produced the highest mean rate of correct digits per min (M = 14.26, SD = 1.36) compared to the social attention (M = 13.4, SD = 1.65) and control (M = 11.12, SD = 1.17) conditions.

**Matt.** Matt’s functional analysis results appear in Figure 7. Visual inspection of Matt’s rate of correct digits per min reveals a differentiated pattern of responding across conditions. Overall, apart from a lower level of responding in the 2nd session, the escape condition produced a higher rate of correct digits per min relative to the other conditions. Summary statistics appear in Table 1. Here too the escape condition produced the highest mean rate of correct digits per min (M = 6.30, SD = 1.02) relative to the social attention (M = 5.73, SD = 0.25) and control (M = 4.68, SD = 0.87) conditions.

**Shannon.** Shannon’s functional analysis results appear in Figure 8. Examination of Shannon’s rate of correct digits per min shows a differentiated pattern of responding across conditions. The escape condition produced stable responding, whereas the other two conditions produced greater variability and lower levels of responding. Summary statistics appear in Table 1. The escape condition produced the highest mean rate of correct digits per min (M = 24.1, SD = 0.12) compared to the social attention (M = 19.8, SD = 5.07) and control (M = 13.1, SD = 7.41) conditions.

**Summary.** Once exposed to the escape condition, all four participants showed a preference for it. The four participants demonstrated differentiated patterns of
responding across the functional-analysis conditions and, therefore, experimental control was achieved. However, it took time for two of the participants (Hillary and Jamie) to discriminate the reinforcement contingencies. This may have been partly due to the fact that the social attention condition resembled natural contingencies in the classroom context (i.e., contingent praise from teachers) whereas the escape condition was novel. Yet, repeated exposure to the conditions resulted in a preference for escape. That is, relative to the social attention and control conditions, escape produced the highest rates of correct digits per min for each participant. These results suggest that the participants’ academic responding was under a negative reinforcement contingency. Thus, the participants met the selection criteria for the current study.

**Experimental Analysis**

The experimental analysis examined the effects of antecedent- and consequence-based strategies on math computation fluency to determine which treatment or combination of treatments produced the highest rates of correct digits per min. Results appear in Figures 9 through 12. Results of the experimental analysis indicated that all four treatments produced improvements in responding relative to baseline and that idiosyncratic, differentiated patterns of responding were found across students.

**Hillary.** Hillary’s results are shown in Figure 9. Baseline levels of responding were quite stable. All of the treatment conditions produced immediate increases in Hillary’s responding relative to Baseline. The results were least differentiated in the first session of each condition and grew in differentiation as the analysis progressed, with DNRA producing the highest level of responding relative to all other conditions. The DRA and Task-Choice+DRA conditions produced overlapping data series, and Task
Choice produced the lowest levels of responding relative to the other treatment conditions. Summary statistics appear in Table 2 and effect sizes appear in Table 3 and confirm the findings in the graphical display of the data. The DNRA condition produced the largest effect size (ES = 7.30) and highest mean rate of correct digits per min (M = 29.99, SD = 3.08), followed by the DRA condition (ES = 4.31, M = 25.32, SD = 1.06), Task-Choice+DRA condition (ES = 3.31, M = 23.76, SD = 0.57), and Task-Choice condition (ES = 2.0, M = 21.72, SD = 0.54), respectively. According to Cohen’s (1988) criteria, all of the effect sizes for each intervention are considered large.

Hillary’s results were also analyzed using the CDC method. In order for a given intervention to be significant, all 5 treatment data points for each condition needed to fall above both criterion lines. Based on this method, Hillary demonstrated a significant difference between the Baseline and intervention phases for all four treatments, as all 5 data points for each intervention fell above both lines. When the CDC method was used to make comparisons between intervention conditions, there was a significant treatment effect for the DNRA condition relative to the Task-Choice and Task-Choice+DRA conditions. Additionally, there was a significant treatment effect for the DRA condition compared to the Task-Choice and Task-Choice+DRA conditions as well as a significant treatment effect for the Task-Choice+DRA condition relative to the Task-Choice condition.

Jamie. Jamie’s results are presented in Figure 10. Baseline levels of responding were stable. All of the treatment conditions produced immediate increases in responding relative to Baseline and results for each condition remain relatively stable. The degree of differentiation is somewhat less for Jamie than for Hillary, but clear patterns do emerge.
Apart from the 2nd session, DNRA and DRA conditions produced comparable results. Task Choice+DRA produced the next highest levels of responding, followed by the Task-Choice condition. Summary statistics appear in Table 2 and effect sizes appear in Table 3. These analyses produced results comparable to the graphical data displays. The DNRA condition produced the largest effect size (ES = 6.65) and highest mean rate of correct digits per min (M = 15.6, SD = 0.66), followed closely by the DRA condition (M = 15.04, SD = 1.12), Task-Choice+DRA condition (M = 14.24, SD = 1.12), and Task-Choice condition (M = 12.72, M = 0.30), respectively. In accordance with Cohen’s (1988) criteria, the effect sizes for the interventions are considered large.

The results of the CDC analysis also provide evidence of differences across treatment conditions for Jamie. In order for a given intervention to be significant, all 5 treatment data points for each condition needed to fall above both criterion lines. Based on this method, Jamie demonstrated a significant difference between the Baseline and intervention phases for all four treatments, as all 5 data points for each intervention fell above both lines. When the CDC method was used to make comparisons between intervention conditions, there was a significant treatment effect for the DNRA condition relative to the Task-Choice and Task-Choice+DRA conditions. Additionally, there was a significant treatment effect for the DRA condition compared to the Task-Choice condition as well as a significant treatment effect for the Task-Choice+DRA condition relative to the Task-Choice condition.

**Matt.** Matt’s results appear in Figure 11. Greater variability during Baseline was observed for Matt than for Hillary and Jamie. Matt’s level of responding dropped considerably (by over half) in the last two sessions of Baseline. All four treatment
conditions produced immediate and stable changes in responding, with all exceeding the Baseline results. For Matt, Task Choice+DRA and DRA produced the highest levels of responding. Data series for these two conditions were overlapping. DNRA produced the next highest level of responding. Task-Choice produced the lowest levels of responding relative to the other three treatment conditions. Summary statistics appear in Table 2 and effect sizes appear in Table 3. The DRA condition produced the largest effect size (ES = 2.96) and highest mean rate of correct digits per min (M = 8.72, SD = 0.48), followed closely by the Task-Choice+DRA condition (ES = 2.91, M = 8.64, SD = 0.17), DNRA condition (ES = 2.05, M = 7.2, SD = 0.21), and Task-Choice condition (ES = 1.55, M = 6.36, SD = 0.17), respectively. According to Cohen’s (1988) criteria, the effect size for each intervention is considered large.

According to the CDC method, all 5 treatment data points for each condition needed to fall above both criterion lines in order for a given intervention to be significant. Based on this method, Matt demonstrated a significant difference between the all four treatments and Baseline. When the CDC method was used to make comparisons between intervention conditions, there was a significant treatment effect for the DRA condition compared to the Task-Choice and DNRA conditions. Additionally, there was a significant treatment effect for the Task-Choice+DRA condition relative to the DNRA and Task-Choice conditions. Finally, there was a significant treatment effect for DNRA compared to the Task-Choice condition.

**Shannon.** Shannon’s results are displayed in Figure 12. Baseline levels of responding are low and decreasing across the three sessions. Shannon’s results were more undifferentiated and less stable than those of the other participants, with changes in trend.
being a prominent feature of the data. Overall, all four treatments generally produced higher levels of responding than Baseline (with the first session of the Task-Choice condition being the exception). An interesting pattern emerged in the results. The conditions were differentiated in the first session of the treatment phase (session 4), converged, and then emerged in a differentiated fashion by the penultimate session (#8), finishing by session 9 in the same order of effect as in session 4 (the first treatment-phase session). The increasing trends would appear to suggest that there was a practice effect, and the pattern of differentiation—undifferentiation—differentiation may indicate that she was testing the various contingencies following an initial preference (session 4) before settling on a preferred order of conditions (sessions 8 and 9). Summary statistics appear in Table 2, and effect sizes appear in Table 3. The DNRA condition produced the largest effect size (ES = 6.48) and highest mean rate of correct digits per min (M = 27.75, SD = 7.49), followed by the Task-Choice+DRA condition (ES = 4.77, M = 23.27, SD = 4.43), DRA condition (ES = 4.72, M = 23.13, SD = 6.99), and Task-Choice condition (M = 18.5, SD = 7.37), respectively. In accordance with Cohen’s (1988) criteria, the effect sizes for the interventions are considered large.

According to the CDC analyses, in order for a given intervention to be significant, all 6 treatment data points for each condition needed to fall above both criterion lines. Accordingly, Shannon demonstrated a significant difference between three of the four treatment conditions (i.e., DRA, DNRA, Task Choice+DRA) and Baseline. In the Task-Choice condition, only 5 of the 6 data points fell above both criterion lines; thus, there was not a significant difference between the Task-Choice condition and Baseline. When
the CDC method was used to make comparisons between treatment conditions, there were no significant effects for any of the interventions relative to other interventions.

**Summary.** Experimental control was established for all four participants as evidenced by differentiated responding at one point or another across treatment conditions, with Hillary, Jamie, and Matt producing the clearest differences between treatments. There were interesting similarities and differences between participants. The DNRA condition produced the highest rates of responding for all but one participant (Hillary, Jamie, and Shannon), whereas the Task-Choice condition consistently produced the lowest rates of responding for all four participants. Additionally, for three of the four participants (Hillary, Jamie, and Matt), DRA produced higher levels of responding than the Task-Choice+DRA condition.
CHAPTER 4

Discussion

The purpose of this study was to examine the effects of choice and differential reinforcement on the math computation fluency of students whose performance appeared to be under the control of a negative reinforcement contingency. The study was designed to answer four research questions. First, can choice effects be replicated when applied to math computation fluency for students whose low rates of math computation fluency were due to escape? Second, how well does task choice improve students’ math computation fluency when compared to consequence-based strategies? Third, can a combined treatment of Task Choice plus DRA produce larger improvements in math computation fluency than the single-component treatments (Task Choice, DRA, DNRA)? Fourth, how do consequence-based treatments (i.e., DNRA and DRA) compare to one another in improving the math computation fluency of students whose low academic performance appeared to be escape-maintained? Prior to the experiment proper, functional analyses were conducted to identify elementary-school students whose behavior appeared to be under the control of a negative reinforcement contingency when given math computation worksheets. Preference assessments also were administered to each student to identify potentially effective reinforcers to use during both DRA conditions of the experimental analysis. To answer the research questions, experimental analyses were conducted with all four participants whereby following a Baseline phase, four treatments – Task Choice, DRA, Task Choice+DRA, and DNRA – were rapidly alternated with counterbalancing within a multielement design. Overall, the results confirm some but not all of the hypotheses generated for the research questions, indicate
that differential reinforcement is superior to task choice, and raise intriguing questions about the idiosyncratic nature of the variables governing the participants’ math computation fluency. DNRA was highly effective for Hillary, Jamie, and Shannon. For Jamie, DRA was as effective as DNRA. For Matt, the positive reinforcement conditions (Task Choice+DRA and DRA) were most effective, followed by DNRA. When DNRA was more effective than the other treatment conditions (Hillary and Shannon), positive reinforcement conditions came in second place. Interestingly, Task Choice+DRA and DRA were equally effective for Hillary and Shannon. Task choice was the least effective intervention for all participants.

Research Question 1: Can choice effects be replicated when applied to math computation fluency for students whose low rates of math computation fluency were due to escape?

Within the literature, most studies have focused on the effectiveness of choice making interventions on students’ task engagement, work completion, and problem behavior (e.g., Dunlap et al., 1994; Umbreit & Blair, 1996; Vaughn & Horner, 1997), demonstrating positive treatment outcomes. Only a limited number of studies have examined the effects of choice making on students’ academic responding (Morgan, 2006). Among these studies, researchers have found that choice-making interventions can improve students’ assignment accuracy, task completion, and oral reading fluency (e.g., Cosden et al., 1995; Daly et al., 2006; Moes, 1998; Ramsey et al., 2010). In light of these positive findings, choice-making was applied to an academic area that has yet to be examined in the literature – math computation fluency – to determine if the effects of
choice could be replicated among students with escape-maintained academic performance problems.

It was hypothesized that task choice would result in higher levels of math computation fluency relative to baseline levels of performance. The results of the current study confirm the first hypothesis. For all four participants, task choice produced higher rates of correct digits per min than baseline for all forms of analyses conducted (visual analysis, effect sizes, and CDC). This may be the first study to demonstrate the effectiveness of task choice on the math computation fluency of students whose computation fluency appeared to be controlled more by a negative-reinforcement contingency than by a positive-reinforcement contingency. These results provide preliminary support for the use of choice-making interventions in the classroom to improve students’ math computation fluency. Future research should seek to replicate the findings of the current study with other school populations (e.g., middle- and high-schoolers), as well as other areas of academic responding (e.g., writing, spelling) that have received limited attention in the literature. Additionally, future research should include a follow-up phase in order to examine the long-term effects of choice-making interventions over time. Given how simple it is to administer a task-choice intervention, future research could investigate class-wide applications.

The findings of the current study raise important questions about the variables governing the effects of choice making for math computation fluency. In the current study, task choice improved the computation fluency of students whose behavior appeared to be responsive to a negative reinforcement contingency. Baseline and task-choice conditions were designed such that the math worksheets in the current study were
equivalent in terms of the number of problems and difficulty level. The only differences in the math worksheets between the conditions were the arrangement of problems on the page and the presence or absence of different types of clip art. Prior research suggests some plausible explanations regarding the mechanism(s) that may be responsible for the effectiveness of choice making on responding. On the one hand, task choice may allow students to avoid a more aversive task by selecting a more preferred task, creating an abolishing operation that reduces the momentary effectiveness of escape (Dunlap et al., 1991; 1994; Jolivette et al., 2001; Powell & Nelson, 1997; Romaniuk et al., 2002). On the other hand, task choice may allow students to select a condition associated with a more desirable stimulus arrangement, establishing the selected task as being more reinforcing (Fisher, Thompson, Piazza, Crosland, & Gotjen, 1997). These explanations do not necessarily contradict one another; both may be true to one degree of another. However, it is not possible at this time to determine whether one, both, or neither are entirely true. What is clear is that the combination of choice and modest stimulus manipulations to differentiate the response options appears to have been sufficient to increase responding relative to baseline. Untangling the positive-reinforcement versus negative-reinforcement knot has proven to be elusive (Iwata, 1987; Michael, 1975) and even delineating whether there is an abolishing or an establishing operation in basic research has been difficult (Fisher et al., 1997). Fortunately, the field does not need to wait for this conceptual issue to be resolved before recommending simple classroom interventions that may improve academic performance. It is interesting to note, however, that in the current study the participants did not consistently select a particular math worksheet (i.e., Form A, B, or C) during the task choice sessions nor routinely avoid choosing one of the three different
kinds of math worksheets. Thus, the effects of choice may indeed have transcended preference, suggesting that choice may introduce stimulus variations that are more reinforcing than the option to select a preferred task under some conditions, which would be a slightly different MO effect. Regardless of which explanation better accounts for the effectiveness of choice-making on students’ responding in this study, all are in agreement as to the potential preventative function of choice-making interventions.

Researchers should continue to investigate the degree to which results of functional assessments affect the efficacy of choice-making interventions. More specifically, investigators should conduct a functional assessment prior to implementing a behavioral intervention involving choice in order to examine the effects of choice-making on problem behaviors that are maintained by various functions (e.g., access to tangible items, escape from academic demands). In this way, it can be determined who will be the most likely candidates to benefit from choice-making interventions. In addition, studies should explore if relationships exist between choice variables (e.g., types of choices that are available, number of items from which to choose) and the underlying function(s) of an individual’s behavior. In doing so, the results could guide the treatment selection process to ensure that choice-making interventions are designed to maximize positive outcomes.

Research Question 2: How well does task choice improve students’ math computation fluency when compared to consequence-based strategies?

There is substantial evidence demonstrating the effectiveness of consequence-based interventions like DRA and DNRA for decreasing students’ escape-maintained problem behavior (e.g., noncompliance, aggression, disruptive or self-injurious
behaviors) and increasing alternative, desirable behavior such as compliance, work completion, and task engagement (e.g., Carr et al., 1980; Geiger et al., 2010; Golonka et al., 2000; Marcus & Vollmer, 1995; Piazza et al., 1996; Vollmer et al., 1999; Warzak et al., 1987). The antecedent-based intervention of task choice also has demonstrated effectiveness for reducing problem behavior (e.g., off-task behavior, disruptive or self-injurious behavior) and increasing desired behavior (e.g., task engagement, assignment accuracy, oral reading fluency, work completion) among both typically developing students as well as students with disabilities (e.g., Cosden et al., 1995; Daly et al., 2006; Dunlap et al., 1991; 1994; Kern et al., 1998; 2001; Moes, 1998; Morgan, 2006). No studies to date, however, have appeared in the literature comparing the antecedent strategy of task choice to consequence-based strategies. Therefore, the current study compared the antecedent intervention of task choice to the consequence-based strategies of DRA and DNRA to determine which would produce the largest increases in rate of responding.

It was hypothesized that the antecedent intervention of task choice would produce equal effects to the consequence-based treatments of DRA and DNRA in improving the math computation fluency of students with escape-maintained academic performance problems. The results of the current study do not support this second hypothesis. For all four participants, the Task-Choice condition produced smaller effect sizes and visibly lower rates of correct digits per min relative to the DRA and DNRA conditions. The results of the current study suggest rather clearly that differential reinforcement procedures are more effective than task choice for improving students’ academic responding. These findings have direct implications for educators. That is, interventions
incorporating differential reinforcement procedures (DRA or DNRA) should probably be prioritized over task choice when teachers are amenable to using reinforcement procedures in their classroom. They come at a cost in terms of effort and resources (task choice is simpler to administer and more readily available than the tangibles that might be necessary for a DRA procedure), but may be viewed as preferable because of their superior treatment effects. Despite the fact that task choice improved responding over baseline, it did not compete very effectively with DRA and DNRA. This finding is perhaps not surprising, in light of the fact that behavior is primarily controlled by consequences. Antecedents (e.g., discriminative stimuli and MOs) only gain control over behavior by virtue of their pairing with reinforcers or punishers in the first place.

In the current study, only slight modifications were made to the computation worksheets (arrangement of problems on the worksheets and presence or absence of clipart). It is entirely possible that other task features might have produced a more robust effect for choice. For example, future studies could vary the number of items from which to choose or the types of choices that are available. Other studies, however, have allowed students to make choices among different types of academic tasks or to select the order of task completion or the stimulus materials (e.g., specific type of pens, glue, scissors) that would be used (e.g., Dunlap et al., 1994; Moes, 1998; Ramsey et al., 2010). Choices like these may produce better effects than those found in the current study. Given their simplicity and positive nature, researchers should not give up on more subtle antecedent interventions like choice. Besides, some teachers have been known to reject the use of programmed rewards in classrooms. Simple antecedent interventions like task choice may be a first line of attack in the intervention continuum.
**Research Question 3:** Can a combined treatment of task choice plus DRA produce larger improvements in math computation fluency than the single-component treatments (task choice, DRA, DNRA)?

Daly et al. (2006) provided preliminary evidence for the effectiveness of combining choice and programmed reinforcement to improve students’ oral reading fluency. However, the authors did not isolate the independent effects of choice and programmed reinforcement or compare the combined treatment to other evidence-based interventions. Thus, the current study sought to address this limitation by comparing the combined treatment of Task Choice+DRA to single-component interventions (Task Choice, DRA, DNRA) to determine which produces the greatest improvements in students’ math computation fluency.

It was hypothesized that the combination of Task Choice+DRA would produce higher rates of math computation fluency than the single-component treatments (Task Choice, DRA, DNRA). The results of the current study only partially confirm this third hypothesis. For all four participants, the combined treatment of Task Choice+DRA produced visibly higher rates of math computation fluency relative to the Task-Choice condition. However, in comparison to the DRA condition, the combined treatment of Task Choice+DRA produced similar responding for two of the participants (Hillary and Shannon) but higher mean rates of math computation fluency for only one of the participants (Shannon). Similarly, relative to the DNRA condition, the combined treatment of Task Choice+DRA produced visibly higher rates of math computation fluency for only one participant (Matt). Taken altogether, the results of the current study suggest there is little benefit to adding task choice to reinforcement procedures. This
finding has important implications for schools as educators design individualized interventions to increase students’ academic performance. When working with students whose behavior may be under a negative-reinforcement contingency, it may be in educators’ best interest to favor differential reinforcement procedures (DRA and DNRA) whenever possible to attain the maximum effect. Additional studies are warranted to substantiate the findings of the current study. As noted earlier, the task dimensions that were manipulated in the task-choice condition may have not been optimal. Future investigations offering choice of consequence and/or choice of more varied tasks may meet with greater success. Not only would these studies be helpful in demonstrating how to combine choice elements, but they would also enhance our understanding about the benefits, or lack thereof, of combining them and when it would be most appropriate to do so.

**Research Question 4: How do consequence-based treatments (i.e., DNRA and DRA) compare to one another in improving the math computation fluency of students whose low academic performance was escape-maintained?**

Studies comparing the effects of DNRA and DRA suggest that DRA may be more effective in decreasing escape-maintained problem behaviors and increasing desirable behaviors among students (Bouxsein et al., 2011; Carter, 2010; Lalli et al., 1999). However, the majority of these comparative studies targeted task compliance and, therefore, it was unclear whether similar results would be obtained if academic responding was the target behavior. The current study compared DNRA and DRA to determine whether one of these reinforcement procedures is more effective than the other.
in improving the math computation fluency of students whose behavior was responsive to a negative-reinforcement contingency.

It was hypothesized that DRA would produce higher rates of math computation fluency than DNRA. The results of the current study do not confirm this fourth hypothesis. Only one of the four participants demonstrated visibly higher rates of math computation fluency in the DRA condition relative to the DNRA condition. Conversely, two of the participants had noticeably higher rates of math computation fluency in the DNRA condition in comparison to the DRA condition. For the fourth participant, there was overlapping data between the DRA and DNRA conditions but summary statistics indicated higher mean rates of correct digits per min in the DNRA condition.

The results of this study suggest that DNRA was generally more effective than DRA in improving the math computation fluency of students whose academic performance problems were maintained by a negative-reinforcement contingency. However, given the fact that one of the participants did respond more favorably to DRA, there do appear to be somewhat idiosyncratic differences. Thus, when selecting interventions for students whose behavior is controlled by a negative reinforcement contingency, it may be worthwhile to conduct a prior functional analysis comparing a DRA (using items selected from a stimulus-preference assessment) and DNRA to determine which one is more effective.

It is interesting that the functional analyses conducted in this study prior to the experimental analyses provided social attention as the consequence for responding, which was different from the consequence provided in the DRA conditions. The latter was chosen based on the results of a stimulus-preference assessment and were therefore
topographically different from the functional-analysis consequences. Yet, DNRA was still more effective for three of the four participants during the experimental analysis. This finding speaks to the robustness of the functionally appropriate condition across competing alternative reinforcement topographies, suggesting that the functional analyses were in fact effective at identifying students whose behavior was controlled by a negative-reinforcement contingency. Future studies should continue to apply functional-analysis procedures to students’ academic responding prior to comparing functionally appropriate treatments, as was done in the current study. Additionally, since the current study solely targeted students with escape-maintained academic performs problems, it would be worthwhile for future studies to extend the functional analyses and target students whose low academic responding is maintained by other functions such as access to tangibles or social praise.

The results of the current study are inconsistent with previous findings suggesting that DRA is more effective than DNRA for participants whose behavior is controlled by a negative-reinforcement contingency. Previous studies, however, examined task compliance (Bouxsein et al., 2011; Carter, 2010; Lalli et al., 1999), and the current study targeted a very different response class—math computation fluency. Thus, it appears that the effectiveness of differential reinforcement procedures may vary based on the nature of the response class being targeted for improvement. Future studies should examine this finding further in light of the present study. In particular, it would be interesting to examine whether the current findings can be obtained for other forms of academic responding like oral reading fluency, writing, and spelling.
In the current study, the DRA conditions resulted in access to high-preference activities contingent on meeting or exceeding a predetermined criterion (i.e., a predetermined number of correctly completed digits). It may be worthwhile for future studies to design DRA conditions that include access to different forms of reinforcement (i.e., high preference edible items, high preference leisure activities, social praise) to determine if treatment differences emerge. The most effective DRA condition could then be compared to DNRA to determine whether similar or different results would be obtained from the current study.

Limitations

Several limitations should be considered when interpreting the results of the current study. First, the Task-Choice condition may not have been designed properly to effectively compete with consequence-based strategies. Within the current literature, there is a lack of research identifying the variables that influence the reinforcing effects of choice-making. For example, it remains unclear whether choice-making is more beneficial if it is provided multiple times per session, if there are a larger number of choice alternatives given to the individual, or if specific types of tasks (i.e., nonpreferred versus preferred) are available to the individual. Given this lack of clarity, there was limited guidance regarding how best to design the Task-Choice condition to optimize the effectiveness of the intervention. Therefore, future research should identify which variables (e.g., the type and number of items available) maximize the benefits of choice-making interventions and subsequently design a choice condition accordingly and compare it to DRA and DNRA to determine whether similar or different results would be obtained from the current study.
A second limitation of the current study is that the task-choice intervention is confounded with the task stimuli (i.e., the task stimuli are embedded in the Task-Choice conditions). Thus, it is difficult to determine why the observed results for the task-choice intervention were obtained. That is, the task stimuli used in the current study could, in whole or in part, be responsible for the obtained results. In any study of choice, task features will be necessarily confounded with the availability of choice, making it virtually impossible to isolate their effects (i.e., the act of choosing versus the task features unique to the choice). Only replications across a variety of task features will perhaps one day resolve this issue.

Third, increasing trends were visible across all four conditions in Shannon’s experimental analysis results. Unfortunately, there was not enough time before the school year ended to collect additional data points to achieve more stability in the data or to implement a return to baseline phase to clarify what is going on with Shannon’s responding. The fact that all four experimental analysis conditions demonstrated an increasing trend as the analysis progressed suggests that something other than the interventions (e.g., practice effects) may have been contributing to the improvements in Shannon’s rate of responding.

A fourth limitation of the current study is that the participants were predominantly elementary-aged female students enrolled in general education classes, limiting the generalizability of the results to other populations for whom math deficits are typical, such as students with a learning disability in mathematics. More research is necessary to determine specific student characteristics that are more responsive to choice-making interventions. These studies might be directed toward determining whether the
reinforcing effects of choice vary across student characteristics such as age, developmental level, and history of choice-making opportunity. For individuals whose behavior appears to be unaffected by choice-making opportunities, additional studies would be beneficial to examine how to establish choice as a reinforcer for them.

Fifth, the current study was not carried out in a typical classroom setting. Rather, experimenters conducted sessions in the school hallway under optimal conditions of administration. Therefore, it is unclear whether the results would generalize to more typical classroom conditions whereby teachers are administering the interventions within the typical classroom setting and curriculum. Future research should extend the analyses of the current study to naturalistic settings (i.e., regular and special education classrooms) to determine if similar results would be obtained.

A sixth and final limitation of the current study is that there is a sequence effect for comparisons with Baseline. Specifically, the effects of the different interventions (i.e., Task Choice, DRA, Task Choice+DRA, and DNRA) may be in part a function of the sequence in which they appeared. That is, since each intervention was preceded by Baseline, this sequence may have influenced all subsequent performances within the intervention conditions. Thus, similar results may not have been obtained if the intervention conditions were preceded by something other than Baseline.

Conclusion

The purpose of this study was to compare the effects of antecedent- and consequence-based treatments on the math computation fluency of elementary-aged students with escape-maintained academic performance problems. In order to identify elementary-school students whose academic responding was under a negative
reinforcement contingency, functional analyses were conducted. A preference assessment was then administered to identify potentially effective reinforcers for use during specific conditions (i.e., DRA and Task Choice+DRA) of the experimental analysis. Finally, following a Baseline condition, a multielement design was conducted to compare the impact of four treatments – Task Choice, DRA, Task Choice+DRA, and DNRA – on students’ math computation fluency. Results demonstrated that 1) all four treatments produced higher rates of math computation fluency compared to baseline levels of performance, 2) reinforcement procedures (DRA and DNRA) were generally more effective than the antecedent intervention of task choice, 3) there were no additional benefits to combining task choice and DRA, and 4) for the majority of the participants DNRA led to greater improvements in math computation fluency than DRA. However, given the idiosyncratic differences among participants regarding the most optimal intervention, it is imperative for schools to conduct functional analyses and to implement individualized, evidence-based treatments.
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### Table 1

**Means and Standard Deviations for the Functional Analysis**

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<th>Rate of Correct Digits Per Min</th>
<th>Condition</th>
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<td>Mean</td>
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<td>Mean</td>
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<td>SD</td>
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*Note. SD = Standard Deviation*
Table 2

*Means and Standard Deviations for the Experimental Analysis*

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<tr>
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<tr>
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<td>SD</td>
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<td>SD</td>
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<tr>
<td>Shannon</td>
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<td></td>
<td>SD</td>
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*Note.* SD = Standard Deviation
Table 3

*Effect Sizes for the Experimental-Analysis Conditions*

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<th>DRA</th>
<th>Task Choice+DRA</th>
<th>DNRA</th>
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*Note.* DRA = Differential Reinforcement of Alternative Behavior; DNRA = Differential Negative Reinforcement of Alternative Behavior
Figure 1. Hillary’s stimulus preference assessment results.
Figure 2. Jamie’s stimulus preference assessment results.
Figure 3. Matt’s stimulus preference assessment results.
Figure 4. Shannon’s stimulus preference assessment results.
Figure 5. Hillary’s functional analysis results.
Figure 6. Jamie’s functional analysis results.
Figure 7. Matt’s functional analysis results.
Figure 8. Shannon’s functional analysis results.
Figure 9. Hillary’s experimental analysis results.
Figure 10. Jamie’s experimental analysis results.
Figure 11. Matt’s experimental analysis results.
Figure 12. Shannon’s experimental analysis results.
## Appendix A

### Math Worksheet and Answer Sheet Example – Screening

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Appendix B

Math Worksheet and Answer Sheet Example – Functional and Experimental Analysis

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<td>2</td>
<td>1 CD/4</td>
<td>3</td>
<td>1 CD/5</td>
</tr>
<tr>
<td>Item 4</td>
<td>1 CD/4</td>
<td>3</td>
<td>3</td>
<td>1 CD/5</td>
<td>2</td>
<td>1 CD/6</td>
</tr>
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</table>

| Item 7 | 1        | 1 CD/7 | 1     | 1      | 1 CD/8 | 3     | 1 CD/9 | 2     | 1 CD/10| 1     | 1 CD/11| 1     | 1 CD/12| 1     |
| Item 8 | 1        | 1 CD/8 | 3     | 1 CD/9 | 2     | 1 CD/10| 1     | 1 CD/11| 1     | 1 CD/12| 1     |        |       |
| Item 9 | 1 CD/9   | 2      | 2     | 1 CD/10| 1     | 1 CD/11| 1     |        |       |        |       |        |       |
| Item 10| 1 CD/10  | 1      | 1     | 1 CD/11| 1     | 1 CD/12| 1     |        |       |        |       |        |       |
| Item 11| 1 CD/11  | 1      | 1     | 1 CD/12| 1     |        |       |        |       |        |       |        |       |
| Item 12| 1 CD/12  | 1      | 1     |        |       |        |       |        |       |        |       |        |       |
Appendix C

Form A Math Worksheet Example

\[
\begin{array}{ccccccc}
2 & + & 1 & & & & \\
+ & 6 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
2 & + & 5 & & & & \\
+ & 3 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
1 & + & 3 & & & & \\
+ & 2 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
5 & + & 2 & & & & \\
+ & 2 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
6 & + & 3 & & & & \\
+ & 4 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
6 & + & 6 & & & & \\
+ & 3 & & & & & \\
\hline
\end{array}
\quad
\begin{array}{ccccccc}
1 & & & & & & \\
+ & 2 & & & & & \\
\hline
\end{array}
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Appendix D

Form B Math Worksheet Example

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<tr>
<td>+</td>
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<td>7</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>2</td>
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<td></td>
<td></td>
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<tbody>
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<td>7</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>2</td>
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<td></td>
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<p>| | |</p>
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<th></th>
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</thead>
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<td></td>
</tr>
<tr>
<td>+</td>
<td>1</td>
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<td></td>
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</table>
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Appendix E
Form C Math Worksheet Example

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<td>+</td>
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<td>7</td>
<td>2</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
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</table>
Appendix F

Reward Survey

Please check off 8 items you believe are most appropriate for the school context and would help motivate the student to complete math problems. Only indicate items that are developmentally appropriate for the student.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Appropriate for the school context and a potential motivator for the student?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Playing outside</td>
<td>☐</td>
</tr>
<tr>
<td>2. Cross-word puzzles</td>
<td>☐</td>
</tr>
<tr>
<td>3. Uno</td>
<td>☐</td>
</tr>
<tr>
<td>4. Word finds</td>
<td>☐</td>
</tr>
<tr>
<td>5. Journaling</td>
<td>☐</td>
</tr>
<tr>
<td>6. Computer time</td>
<td>☐</td>
</tr>
<tr>
<td>7. Drawing</td>
<td>☐</td>
</tr>
<tr>
<td>8. Playing with play dough</td>
<td>☐</td>
</tr>
<tr>
<td>9. Board games</td>
<td>☐</td>
</tr>
<tr>
<td>10. Playing Simon Says</td>
<td>☐</td>
</tr>
<tr>
<td>11. Mad Libs</td>
<td>☐</td>
</tr>
<tr>
<td>12. Crafts (e.g., origami, making friendship bracelets)</td>
<td>☐</td>
</tr>
<tr>
<td>13. Earning a certificate for completing math problems</td>
<td>☐</td>
</tr>
<tr>
<td>14. Connect the dots</td>
<td>☐</td>
</tr>
<tr>
<td>15. Sudoku</td>
<td>☐</td>
</tr>
</tbody>
</table>

Do you have other suggestions?
Appendix G

Multiple-Stimulus without Replacement (MSWO) Protocol

Materials
- Directions to student
- Reward survey
- Stimulus cards
- MSWO recording sheet

Preparation
- 1. Give the reward survey to the students’ teachers.
- 2. Make up stimulus cards for activities (e.g., index card with “uno” written on it).
- 3. Select eight activities in total.

Stimulus Preference Assessment Sessions
- 4. Place the stimulus cards linearly in an array in front of the child and say, “I want to find out what kinds of rewards you like to work for. You will get a chance to earn some later. Each of these cards represents something you can work for.” Read the activity on each card and have the student read it back to you. Make sure that the student understands what each card stands for and what each item is.
- 5. Say, “Which one would you be willing to do math problems for? Pick one.”
  - Answer any questions the student might have. If the student fails to respond, repeat the instruction.
  - After a stimulus is selected, remove the item from the array and reposition the remaining stimuli in the following manner.
    - Shift all items to the right of the chosen item to the left to fill the gap.
    - Shift the item furthest to your left to the place furthest to your right.
    - Reposition the array to be centered in front of the child.
  - Continue this process until all stimuli are selected, marking the MSWO recording sheet with the order of selection after each item (i.e., 1 to 8).
- 6. Repeat this process with the remaining stimulus cards.
- 7. Repeat steps 4 to 6 two more times (preferably on different days) with the same items but randomize the order of the arrays each time.

Analyzing Results
- 8. After three assessments (on separate days), circle the median score (1 to 8) on the stimulus array recording sheet across the three sessions for each stimulus item.
- Convert to rank orderings by reverse scoring. Then, plot rank orderings on a bar graph.
  - The lowest median score (e.g., “1”) receives the highest score of “8”. The next lowest median score receives the next highest score of “7” and so on.
  - In the event of a tie (e.g., top two items receive median scores of “2”), give the mean of the two proximal rankings (e.g., mean of 8 and 7 is 7.5) and do not assign a whole number score for the two most proximal scores (e.g., 8 & 7).
- Color code the bar graph for high preference (7 or 8), medium preference (3-6) and low preference (1 or 2) items to facilitate visual inspection.
Appendix H

MSWO Recording Sheet

Student ______________________

<table>
<thead>
<tr>
<th></th>
<th>Certificate</th>
<th>Cross-Word Puzzles</th>
<th>Connect the Dots</th>
<th>Drawing</th>
<th>Journaling</th>
<th>Reading</th>
<th>Uno</th>
<th>Word Finds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>

Rank Ordering: _______ _______ _______ _______ _______ _______ _______ _______
1 = First chosen, 8 = last chosen
Appendix I

Social Attention Protocol

Materials
- Directions to student
- Multiple math worksheets
- Pencils
- Timer
- Functional-analysis recording sheet
- Audiocassette recorder

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Social Attention).

Presenting Math Worksheets
- 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- 2. Say, “For the next 10 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 10 minutes, I will collect up any work you might have done. Please complete as many problems as you can. Let’s do them together. While you work on the math problems, I will watch and tell you if you are doing a good job. If you finish a math worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS. You can begin.”
- 3. Watch the student complete math problems and give positive social attention (e.g., “Way to go!” “Good job!” etc.) according to the schedule below. If the student stops working on problems at any time before the 10 minutes is up, say, “Please continue working on problems. Do the next problem.”

<table>
<thead>
<tr>
<th>Problem Number:</th>
<th>Problem Number:</th>
<th>Problem Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

- 4. At the end of 10 minutes say, “Time is up. Awesome job completing all of these math problems!”
- 5. Collect all remaining math worksheets and take the student to his or her homeroom classroom.
6. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the functional-analysis recording sheet as well as the date of the session.
## Appendix J

Functional-Analysis Recording Sheet Example

<table>
<thead>
<tr>
<th>Date</th>
<th>Protocol</th>
<th># of Correct Digits</th>
<th># of Breaks?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Escape</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Social Attention</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Escape</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Attention</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Attention</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Escape</td>
<td></td>
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<tr>
<td></td>
<td>Social Attention</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Escape</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Escape</td>
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<tr>
<td></td>
<td>Social Attention</td>
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</tr>
<tr>
<td></td>
<td>Control</td>
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Appendix K

Escape Protocol

Materials
- Directions to student
- Multiple math worksheets
- Pencils
- Timer
- Functional-analysis recording sheet
- Audiocassette recorder

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Escape).

Presenting Math Worksheets
- 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- 2. Say, “For the next 10 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 10 minutes, I will collect up any work you might have done. Please complete as many problems as you can. Each time you finish a math worksheet, I will give you a brief break. You can begin.”
- 3. Supervise the student’s work completion. If the student stops working on problems at any time before completing a math worksheet, say, “Please continue working on problems. Do the next problem.”
- 4. Every time the student completes 12 math problems (i.e., one math worksheet), say, “You can take a break now.” Pick up the math worksheets and allow the student to sit quietly for 30-s. Place a check mark in a box below each time you give the student a break.

|  |  |  |  |  |  |

- 5. During the 30-s break, sit quietly and work on another activity. If the student seeks your attention, say, “I will give you more problems soon. I have to do my work now.”
- 6. Once the 30-s is up, place the next math worksheet in front of the student if there is time remaining in the condition and say, “Continue working on the math problems.” Return to step 3.
- 7. At the end of 10 minutes say, “Time is up.”
8. Collect all remaining math worksheets and take the student to his or her homeroom classroom.

9. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the functional-analysis recording sheet as well as the additional required information (i.e., date of session, number of breaks received).
Appendix L

Control Protocol – Functional Analysis

Materials
- Directions to student
- Multiple math worksheets
- Pencils
- Timer
- Functional-analysis recording sheet
- Audiocassette recorder

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Control – Functional Analysis).

Presenting Math Worksheets
- 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- 2. Say, “For the next 10 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 10 minutes, I will collect up any work you might have done. You can choose to do as much or as little work as you like. However, you must be quiet during this time. If you finish a math worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS.] You can begin.”
- 3. As the student works on the math problems, sit quietly and work on another activity. If the student asks for help or seeks your attention say, “Just do your best.”
- 4. At the end of 10 minutes, say, “Time is up.”
- 5. Collect all remaining math worksheets and take the student to his or her homeroom classroom.
- 6. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the functional-analysis recording sheet as well as the date of the session.
Appendix M
Control Protocol – Experimental Analysis

Materials
- Directions to student
- Multiple math worksheets – Form A
- Pencils
- Timer
- Experimental-analysis recording sheet
- Audiocassette recorder

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Control – Experimental Analysis).

Presenting Math Worksheets
- 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- 2. Say, “For the next 5 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 5 minutes, I will collect up any work you might have done. You can choose to do as much or as little work as you like. However, you must be quiet during this time. If you finish a math worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS.] You can begin.”
- 3. As the student works on the math problems, sit quietly and work on another activity. If the student asks for help or seeks your attention, say, “Just do your best.”
- 4. At the end of 5 minutes, say, “Time is up.”
- 5. Collect all remaining math worksheets and take the student to his or her homeroom classroom.
- 6. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the experimental-analysis recording sheet as well as the date of the session.
Appendix N

Task Choice Protocol

Materials

- Directions to student
- Multiple math worksheets – Form A, B, and C
- Pencils
- Timer
- Experimental-analysis recording sheet
- Audiocassette recorder

Preparation

- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Task Choice).

Presenting Math Worksheets

1. Place three stacks (Form A, B, and C) of math worksheets on the desk. Position one stack of math worksheets to the left of the student, the second stack of math worksheets to the right of the student, and a third stack of math worksheets in the center of the student. Make sure all three stacks of math worksheets are readily accessible to the student and the experimenter, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.

2. Say, “Which stack of math worksheets do you want to work on today?” After the student points to or verbally indicates his or her preference, verify it by picking up the stack of math worksheets and saying, “You want to work on these math worksheets?” If the student says, “yes,” proceed to the next step. If the student says “no,” reposition both stacks of math worksheets and ask the question again (i.e., “Which stack of math worksheets do you want to work on today?”). Remove from the table the stack of math worksheets the student did not choose.

3. Say, “For the next 5 minutes you may work on these math worksheets (DISPLAY THE STACK OF MATH WORKSHEETS THE STUDENT CHOSE). At the end of 5 minutes, I will collect up any work you might have done. Please complete as many problems as you can. If you finish a math worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS.] You can begin.”

4. As the student works on the math problems, sit quietly and work on another activity. If the student asks for help or seeks your attention, say, “Just do your best.”

5. At the end of 5 minutes, say, “Time is up.”
6. Collect all remaining math worksheets and take the student to his or her homeroom classroom.

7. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the experimental-analysis recording sheet as well as the date of the session.
Appendix O

Experimental-Analysis Recording Sheet Example

<table>
<thead>
<tr>
<th>Date</th>
<th>Protocol</th>
<th>Goal</th>
<th>Goal Met?</th>
<th>Reinforcer</th>
<th># of Correct Digits</th>
<th># of Breaks</th>
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</tr>
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Appendix P

Differential Reinforcement of Alternative Behavior Protocol

**Materials**
- Directions to student
- Multiple math worksheets – Form A
- Pencils
- Timer
- Experimental-analysis recording sheet
- Envelope containing note cards with numbers on them
- Activity card
- Audiocassette recorder

**Preparation**
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Differential Reinforcement of Alternative Behavior).

**Selecting Reinforcer**
1. Say, “You can earn a reward for doing math problems today.”
2. Say, “At the end of the session, I will reach in and pick out a number from the envelope. (DISPLAY ENVELOPE FOR STUDENT.) If you correctly complete at least that many digits on the math worksheets then you will earn _________” (PLACE THE ACTIVITY CARD AT THE TOP OF THE DESK. This activity will be pre-chosen by the primary experimenter).

**Presenting Math Worksheets**
3. Place a stack of math worksheets on the desk. Make sure the stack of math worksheets are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
4. Say, “For the next 5 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 5 minutes, I will collect up any work you might have done and tell you whether you earned a reward. Please complete as many problems as you can. If you finish a math worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS.] You can begin.”
5. As the student works on the math problems, sit quietly and work on another activity. If the student asks for help or seeks your attention, say, “Just do your best.”
6. At the end of 5 minutes, say, “Time is up. I am going to see how many digits you got correct.”
7. Collect all remaining math worksheets and refer to the appropriate answer sheets to count the total number of correctly completed digits. Record this number on the experimental-analysis recording sheet as well as the date of the session.

Performance Feedback and Applying Reinforcement Contingency

8. Reach in the envelope, and pull out a note card and say, “The goal for today is [STATE THE NUMBER ON THE NOTE CARD]. If you completed __ or more digits correctly on the math worksheets, you earn ____” (this activity will be pre-chosen by the primary experimenter).

9. Give feedback to the student saying:
   - Met the goal - “You met the goal and earned the reward. Good job! I will allow you to (NAME THE ACTIVITY) for 10 minutes.”
   - Did not meet the goal - “You did not meet the goal today for the reward. I’m sorry. But, you will get another chance to earn a reward in future sessions.”

10. Deliver the reward if the student met the goal. (SET A TIMER FOR 10 MINUTES).

11. Complete the additional information on the experimental-analysis recording sheet (i.e., goal of today’s session and whether or not the goal was met).
Appendix Q

Task Choice Plus Differential Reinforcement of Alternative Behavior Protocol

Materials
- Directions to student
- Multiple math worksheets – Form A, B, and C
- Pencils
- Timer
- Experimental-analysis recording sheet
- Envelope containing note cards with numbers on them
- Activity card
- Audiocassette recorder

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Task Choice Plus Differential Reinforcement of Alternative Behavior)

Selecting Reinforcer
1. Say, “You can earn a reward for doing math problems today.”
2. Say, “At the end of the session, I will reach in and pick out a number from the envelope. (DISPLAY ENVELOPE FOR STUDENT.) If you correctly complete at least that many digits on the math worksheets then you will earn _________” (PLACE THE ACTIVITY CARD AT THE TOP OF THE DESK. This activity will be pre-chosen by the primary experimenter).

Presenting Math Worksheets
3. Place three stacks (Form A, B, and C) of math worksheets on the desk. Position one stack of math worksheets to the left of the student, the second stack of math worksheets to the right of the student, and a third stack of math worksheets in the center of the student. Make sure all three stacks of math worksheets are readily accessible to the student and the experimenter, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
4. Say, “Which stack of math worksheets do you want to work on today?” After the student points to or verbally indicates his or her preference, verify it by picking up the stack of math worksheets and saying, “You want to work on these math worksheets?” If the student says, “yes,” proceed to the next step. If the student says “no,” reposition both stacks of math worksheets and ask the question again (i.e., “Which stack of math worksheets do you want to work on today?”). Remove from the table the stacks of math worksheets the student did not choose.
5. Say, “For the next 5 minutes you may work on these math worksheets (DISPLAY THE STACK OF MATH WORKSHEETS THE STUDENT CHOSE). At the end of 5 minutes, I will collect up any work you might have done and tell you whether you earned a reward. Please complete as many problems as you can. If you finish a worksheet, turn it over and place it here [POINT TO A SPOT THAT IS ACCESSIBLE BUT OUT OF THE STUDENT’S WAY AND DOES NOT INTERFERE WITH WORKING ON OTHER MATH WORKSHEETS.] You can begin.”

6. As the student works on the math problems, sit quietly and work on another activity. If the student asks for help or seeks your attention, say, “Just do your best.”

7. At the end of 5 minutes, say, “Time is up. I am going to see how many digits you got correct.”

8. Collect all remaining math worksheets and refer to the appropriate answer sheets to count the total number of correctly completed digits. Record this number on the experimental-analysis recording sheet as well as the date of the session.

**Performance Feedback and Applying Reinforcement Contingency**

9. Reach in the envelope, and pull out a note card and say, “The goal for today is [STATE THE NUMBER ON THE NOTE CARD]. If you completed ___ or more digits correctly on the math worksheets, you earn ____” (this activity will be pre-chosen by the primary experimenter).

10. Give feedback to the student saying:
    - Met the goal - “You met the goal and earned the reward. Good job! I will allow you to (NAME THE ACTIVITY) for 10 minutes.”
    - Did not meet the goal - “You did not meet the goal today for the reward. I’m sorry. But, you will get another chance to earn a reward in future sessions.”

11. Deliver the reward if the student met the goal. (SET A TIMER FOR 10 MINUTES).

12. Complete the additional information on the experimental-analysis recording sheet (i.e., goal of today’s session and whether or not the goal was met).
Appendix R

Differential Negative Reinforcement of Alternative Behavior Protocol

Materials

- Directions to student
- Multiple math worksheets – Form A
- Pencils
- Timer
- Experimental-analysis recording sheet
- Audiocassette recorder

Preparation

- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.
- As the student is being seated, turn on the audiocassette recorder. State the date and the phase being conducted (e.g., Differential Negative Reinforcement of Alternative Behavior).

Presenting Math Worksheets

- 1. Place a stack of math worksheets on the desk so they are readily accessible to the student and the experimenter but are not directly in front of the student, saying to the student, “I am putting math worksheets here so you can easily reach them. Are they close enough for you to reach them?” If the student says, “no,” reposition the math worksheets and ask the question again. When the student replies, “yes,” or the equivalent, follow the next step.
- 2. Say, “For the next 5 minutes you may work on these math worksheets (DISPLAY FOR STUDENT). At the end of 5 minutes, I will collect up any work you might have done. Please complete as many problems as you can. Each time you finish a worksheet, I will give you a brief break. You can begin.”
- 3. Supervise the student’s work completion. If the student stops working on problems at any time before completing a math worksheet, say, “Please continue working on problems. Do the next problem.”
- 4. Every time the student completes 12 math problems (i.e., one math worksheet), say, “You can take a break now.” Pick up the math worksheet and allow the student to sit quietly for 30-s. Place a check mark in a box below each time you give the student a break.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

- 5. During the 30-s break, sit quietly and work on another activity. If the student seeks your attention, say, “I will give you more problems soon. I have to do my work now.”
- 6. Once the 30-s is up, place the next math worksheet in front of the student if there is time remaining in the condition and say, “Continue working on the math problems.” Return to step 3.
7. At the end of 5 minutes say, “Time is up.”
8. Collect all remaining math worksheets and take the student to his or her homeroom classroom.
9. Refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the experimental-analysis recording sheet as well as the additional required information (i.e., date of session and number of breaks received).
Appendix S

Screening Protocol

Materials
- Directions to student
- Multiple math worksheets
- Pencils
- Timer
- Screening recording sheet

Preparation
- Ask the student to be seated at a desk or table, depending on the room, so that you can give directions.

Presenting Math Worksheets
1. Give the student a pencil and a math worksheet, placing the math worksheet face-down. Hold up a sample math worksheet and say, “You are going to do some math problems now. As soon as you get your paper, write your first name and the date at the top of the paper. Then put your pencil down so I know you are ready for the next directions.”
2. When the student has finished writing his or her name and date on the backside of the math worksheet, say, “You will have 2 minutes to do math problems. When I say “Start,” turn your paper over and begin working. You’ll start on the first problem at the top on the left side (Point). Work across the page and then go down to the next row. If you complete the first page, work on the second page. If you can’t answer a problem, skip it and go to the next one. You’ll work until I say “Stop.” Ready? Turn your paper over and you can begin.” (Start the stopwatch).
3. As the student works on the math problems, sit quietly and work on another activity.
4. At the end of 2 minutes say, “Time is up.”
5. Collect the math worksheet and refer to the appropriate answer sheet and count the total number of correctly completed digits. Record this number on the screening recording sheet as well as the date the math worksheet was administered.
6. Continue to administer all of the math worksheets on a student’s list. Repeat steps 1 to 4 when administering each math worksheet.
Appendix T

Screening Recording Sheet Example

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<td>Multiplication facts: 0 to 9</td>
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<td>Screening Probe 7</td>
<td>2-digit number from a 2-digit number: regrouping – subtraction</td>
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<tr>
<td>Screening Probe 6</td>
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</tr>
<tr>
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<td>Two 2-digit numbers: no regrouping – addition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screening Probe 3</td>
<td>Two 1-digit numbers – subtraction</td>
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<table>
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