ASSESSMENT OF INFLUENTIAL DIMENSIONS OF REINFORCEMENT AND CORRESPONDING ACADEMIC INTERVENTIONS

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By

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ABSTRACT

A two-part experiment was conducted to evaluate the effectiveness of an intervention derived from an assessment of dimensions of reinforcement. In Study 1, a computer-based assessment was administered to determine the effect of differing dimensions of reinforcement on response allocation. Participants were presented with two sets of math problems in which reinforcer rate, quality, or response effort competed directly with immediacy to assess impulsive responding. Immediacy was varied across the two experimental conditions to determine if impulsive choices were more likely to occur when delays to the delivery of the terminal reinforcer were present (Delay to Exchange) or when delays to the delivery of conditioned reinforcers were present (Delay to Point). Results indicated that reinforcer quality was influential for all 3 participants along with rate (for 2 participants) and immediacy to exchange (for one participant). In Study 2 an intervention was developed that manipulated influential dimensions to increase the rate of correct completion of two-digit times one-digit arithmetic problems for two of the participants from Study 1. Results showed an increased rate of correct problem completion for both participants. Results are discussed with respect to the effectiveness of interventions based on results from the computer-based assessment.
I would like to dedicate this thesis to my parents, Stan and Geneva Thoman.
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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Educational professionals are increasingly being called upon to provide assessment based interventions to students with disruptive behaviors. When a student exhibits disruptive behavior, it can be interpreted as the selection of that response to the exclusion of more desirable responses. Disruptive behavior is maintained when it produces reinforcement. Often, the same or similar reinforcers could be obtained with a more desirable behavior. It has been hypothesized that when students choose disruptive responses, it is likely they do so because of a difference in the dimensions of reinforcement for that response alternative compared to a more desirable alternative. The focus of Study 1 was to assess which particular dimensions of reinforcement affected participants’ choices. The focus of Study 2 was to determine if influential dimensions could be manipulated in order to promote more beneficial behavior choices.

Various methods have been developed to reduce disruptive and off-task behaviors. Common interventions have included medication (Dicesare, McAdam, Toner, & Varrell, 2005; Northup, et al. 1999), extinction (Magee & Ellis, 2000; Richman, Wacker, Asmus, & Casey, 1998), differential reinforcement (Conyers, et al., 2004), response cost (Keeney, Fisher, Adelinis, & Wilder, 2000), time out (Foxx & Shapiro, 1978; Plummer, Baer, & LeBlanc, 1977), token economies (Kazdin, 1982), contracting (White-Blackburn, Semb, & Semb, 1977), and self-monitoring (Armstrong, 2002;
Brooks, Todd, Tofflemoyer, & Horner, 2003; Rock, 2005). A concurrent schedules approach provides behavior analysts with another option to decrease disruptive and off-task behaviors.

**Concurrent Schedules of Reinforcement**

According to Cooper, Heron, and Heward, (1987), “A schedule of reinforcement is a rule that establishes the probability that a specific occurrence of a behavior will produce reinforcement,” (276). All reinforcement schedules exist on a continuum between a continuous schedule of reinforcement and extinction.

When behaviors are maintained by different schedules of reinforcement, different response patterns emerge. A continuous schedule of reinforcement will, by definition, cause the behavior to increase. Characteristics of FI and FR schedules include a post-reinforcement pause followed by an increased level of responding. VI and VR schedules provide more consistent, stable responding over time without a post-reinforcement pause. Extinction has several characteristics. An initial increase in frequency and magnitude will be observed. This will be followed by a gradual decline. Another feature of extinction is the spontaneous recovery, or sudden increase in frequency, which can occur after behavior has been maintained at a low level (Cooper, Heron, & Heward, 1987).

Concurrent schedule arrangements have been shown to influence responding. Concurrent schedules of reinforcement exist any time two or more schedules of reinforcement are in place for alternative responses. According to McDowell (1988) each response alternative must be on an intermittent schedule. The individual must also be free to alternate behavior continuously between the response alternatives. Several studies
have used concurrent schedules to decrease problem behavior and/or increase desirable behaviors (Hoch, McComas, Johnson, Franda, & Guenther, 2002; Hoch, McComas, Thompson, & Paone, 2002; Lalli & Casey, 1996; Piazza, et al., 1997). Each of these studies demonstrated that individuals are sensitive to changes in concurrent schedule arrangements.

Concurrent schedules have been used as an effective tool to decrease problem behaviors without the use of extinction. This is beneficial for applications where the negative effects of extinction, such as an increase in rate and magnitude of problem behavior (Cooper, Heron, & Heward, 1987), must be avoided. Piazza et al. (1997) manipulated the schedules of reinforcement for compliance and destructive behavior. Reinforcers that were manipulated included a break, tangible items, or attention. Results indicated that two of three participants responded to the contingencies, while one participant’s behavior required the use of extinction procedures.

Hoch, McComas, Thompson, and Paone (2002) also used a concurrent schedules arrangement and avoided the negative effects of escape extinction. Participants’ problem behavior was maintained by negative reinforcement in the form of escape from task. During this study task completion resulted in negative reinforcement and access to preferred activities while problem behavior also resulted in negative reinforcement. This concurrent schedule arrangement resulted in an increase in task completion and a decrease in problem behavior.

In essence, the previous studies demonstrated that participants will allocate responses on concurrent schedules based on the relative strength of reinforcer available.
for each response alternative. These studies also show that dimensions of reinforcement, in this case quality of reinforcement, can be manipulated in applied settings.

**Choice**

A choice occurs when an individual selects one response alternative to the exclusion of others (McDowell, 1988). Munk and Repp (1994) identified choice as an important instructional variable. They cited several studies that have shown choice to be an effective intervention (e.g. Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Dyer, Dunlap, & Winterling, 1990; Mithaug & Mar, 1980; Parson, Reid, Reynolds, & Baumgarner, 1990).

Choice has also been studied as a dependent variable. Fisher and Mazur (1997) described the benefits of studying choice in a concurrent operants arrangement. A single operant arrangement restricts the evaluation of preference to comparative rates of performance on each operant. When comparative rates of performance on a single operant schedule yield similar results this suggests the operants are equally preferred. In a concurrent operants arrangement, two or more operants are placed in direct competition with each other. When operants are placed in direct competition a clearer preference is demonstrated because the selection of one involves the exclusion of the other. Different factors will affect how individuals choose to allocate responding. Generally, responses will be emitted according to the principles of the Matching Law.

**Matching Law**

The Matching Law was first proposed by Herrnstein (1961). The basic premise of the Matching Law is that the relative rate of responding will equal the relative rate of
reinforcement on concurrent schedules. When multiple response options are available, an individual will make choices that will maximize reinforcement.

In order to maximize reinforcement, responses must be allocated differently when different types of reinforcement schedules are in effect. The Matching Law also describes how different types of schedules of reinforcement affect response allocation. When two concurrent variable interval (VI) schedules are in place (e.g. VI 30 s, VI 60 s) responses will be allocated in such a way that maximizes reinforcement. In the above example three reinforcers are available within a 60 s time period (two on the VI 30 s, one on the VI 60 s). The Matching Law would predict that two-thirds of responses would be allocated to the response alternative on the richer schedule.

Concurrent variable ratio schedules (VR) provide contrasting results, but still adhere to the predictions of Matching Law. Assume a concurrent VR VR arrangement (e.g. VR 3, VR 6). On concurrent ratio schedules Matching Law predicts 100% of responses will be allocated to the richer schedule of reinforcement when all other variables remain constant. This occurs because total reinforcement is decreased when a participant switches between response alternatives (Fisher & Mazur, 1997). Responses are allocated to a fixed ration (FR) schedule in a similar fashion.

Matching has been discussed in terms of percentage of response allocation and percentage of reinforcers obtained. Myerson and Hale (1984) assert that time based matching is a more fundamental relationship than response allocation. This becomes evident when considering two response options that require different amounts of effort to complete. For example, if the target behavior is problem completion, then it will take a
greater amount of time to complete three-digit times three-digit multiplication problems than one-digit times one-digit multiplication problems. The majority of responses could be allocated to the one-digit problems, but the majority of time may be allocated to the three-digit problems.

Departures from matching law have been noted (Baum, 1974, 1979; Fuqua, 1984). Overmatching occurs when the relative rate of the more frequent response is greater than the relative rate of reinforcement delivered for that response. Undermatching occurs when the relative rate of the more frequent response on a richer schedule is less than the relative rate of reinforcement delivered for that response (Mace, Neef, Shade, & Mauro, 1994). Another deviation from matching is bias. Bias occurs when an individual consistently allocates responding in a manner not predicted by simple matching (Fisher & Mazur, 1997). Several studies have examined the factors that affect responding in comparison to the Matching Law in an attempt to identify variables that would cause an individual to deviate from matching. Horne and Lowe (1993) examined how rule-governed behaviors caused participants to allocate responses in a manner that may or may not have maximized reinforcement. Other studies have examined how altering the dimensions of reinforcement on concurrent response options have caused individuals to deviate from matching (Mace, Neef, Shade, & Mauro, 1996; Neef, Mace, & Shade, 1993; Neef, Shade, & Miller, 1994).

Dimensions of Reinforcement

Differing dimensions of reinforcement have been shown to cause bias according to the Matching Law. Peterson, Neef, Van Norman, and Ferreri (2005) describe some of
the factors that affect choice. Among the factors discussed are the dimensions of reinforcement, rate, quality, response effort, and immediacy.

Rate of reinforcement refers to the number of reinforcers delivered per unit of time. Rates can be set up on both ratio and interval reinforcement schedules. These rates can be manipulated so that a concurrent VR VI arrangement could yield an equal density of reinforcement (Flora & Pavlik, 1992).

Quality of reinforcement is based on an individual’s preference for certain reinforcers. In a school setting, a student may prefer extra recess time to bonus points. In a workplace situation, an employee may prefer a better benefits package to a higher salary. Quality is measured only against an individual’s preferences and comparisons between individuals are seldom beneficial. It is also important not to confuse quality of reinforcement with magnitude of reinforcement, which is simply differing amounts of the same reinforcer (e.g., $1.00 compared to $100.00). Quality and magnitude have been manipulated to cause an increase in desired play activities (Hoch, et al., 2002).

Immediacy of reinforcement can be observed by measuring the delay between the emission of the response and the delivery of the reinforcer. In concurrent schedule arrangements, immediacy is also defined in relative terms. Delays will either be equal or unequal. If delays are unequal then they will not only be defined in absolute terms (e.g. one minute, one day), but also relative terms (sooner, later).

The last dimension of reinforcement is response effort. Individuals’ capabilities will be the primary determinant of what they view as a high effort or low effort task.
Friman and Poling (1995) reviewed the affects of manipulating response effort on both increasing and decreasing behavior.

Lalli and Casey (1996) tracked compliance in a child who exhibited aggressive behavior. By altering the dimensions of rate and quality they produced a reduction in aggression and an increase in compliance without the use of extinction procedures. A concurrent schedule arrangement that reinforced aggression (by escape), and compliance (by escape plus social interaction) was used. This was necessary because the child’s aggression was too severe to be placed on extinction (i.e., any increase in frequency or magnitude would have been unacceptable).

Several studies have examined how the dimensions of reinforcement affect response allocation (Mace, Neef, Shade, & Mauro 1994, 1996; Neef, Bicard, & Endo 2001; Neef, Bicard, Endo, Coury, & Aman, 2005; Neef & Lutz, 2001a, 2001b; Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994; Neef, et al., 2005). These studies examined participants’ response and/or time allocation patterns on concurrently presented sets of math problems. Reinforcers were available for completion of problems on each set, but the dimensions of reinforcement varied.

Neef, Mace, Shea, and Shade (1992) examined participants’ sensitivity to rate and quality of reinforcement. They demonstrated that a countdown timer was needed to help participants develop sensitivity to changes in rate of reinforcement. Once this sensitivity was developed, participants allocated responding as predicted by the matching law when alternative responses produced reinforcers of equal quality. However, when reinforcers differed in quality (nickels versus program money), the matching relation was disrupted.
The percentage of time allocated to the lean schedule that produced the high quality reinforcers was greater than the percentage of reinforcers obtained on that set, showing undermatching. Mace, Neef, Shade, and Mauro (1994) also examined the necessity of using adjunct procedures to sensitize participants to changes in rates of reinforcement. Time allocation data showed a linear relationship with rate of reinforcement, but showed undermatching until adjunct procedures were implemented, replicating Neef, Mace, Shea, and Shade’s results.

In a follow up study, Neef, Mace, and Shade (1993) examined the interactive effects of reinforcer rate, delay, and quality in students with serious emotional disturbance. In Study 1 high rates of reinforcement competed with immediacy of reinforcement. Students showed impulsivity by not maximizing reinforcement on the VI schedules consistently, but opting for the immediate delivery of the reinforcer. Study 2 involved a participant that allocated more responding to response alternatives that produced high quality reinforcers. Rate was not an influential dimension for this participant. The study was designed to test this preference by setting up conditions that would evaluate the effect immediacy had on response allocation to high quality reinforcers. The first session was a delayed high quality rich schedule versus immediate low quality lean schedule. The second session was a delayed high quality lean schedule versus immediate low quality rich schedule. Results indicated that differing reinforcer dimensions affect response allocation in an idiosyncratic manner.

An extension of previous research, Neef, Shade, and Miller (1994) examined how the dimensions of reinforcement affected responding when placed in direct competition
with one another. Each experimental condition involved concurrent schedules that differed on two of the four dimensions. Sessions conducted included: rate versus quality, rate versus effort, rate versus immediacy, quality versus effort, immediacy versus quality and immediacy versus effort. Preferences for dimensions were idiosyncratic. Four students completed the experimental conditions with procedures similar to Neef, Mace, Shea, and Shade (1992) and Neef, Mace, and Shade (1993). The remaining two participants completed the assessment using a computer program.

In an extension that focused on effort, quality and rate of reinforcement, Mace, Neef, Shade, and Mauro (1996) examined the interactive effects of effort and quality on completion of mathematics problems with differing rates of reinforcement. Rate of reinforcement was influential when it competed with effort. However, high quality reinforcers paired with a low rate of reinforcement received a majority of time allocation when it competed with low quality/high rate. This indicated quality was influential.

Two participants from the study conducted by Neef, Shade, and Miller (1994) completed the assessment of dimensions of reinforcement using a computer program. Neef and Lutz (2001b) described a similar computer-based assessment designed to test the differential responsiveness to rate, quality, delay, and response effort. Participants allocated responding in an idiosyncratic manner. Eight of the 11 participants had patterns of responding that showed preference for a single dimension.

Using a similar computer-based assessment, Neef and Lutz (2001a) completed an assessment of reinforcer and response dimensions, and found that time allocation was differentially affected. The assessment results were then used to develop classroom based
interventions designed to decrease participants' rate of disruptions. For example, immediacy was most influential for one participant (Damien). Therefore immediate and delayed reinforcer conditions were alternated in a reversal design. Data indicated that the level of disruptions decreased when contingent reinforcement was delivered immediately.

Observations from the previous research and the classroom led to the hypothesis that participants with attention deficit hyperactivity disorder (ADHD) often make impulsive choices. Impulsive choices occur when a participant chooses a smaller, more immediate reinforcer over a larger, delayed one. More generally, the term temporal discounting refers to the weakening of consequence effects due to delay in reinforcement (Critchfield & Kollins, 2001). Neef, Bicard, and Endo (2001) used the computer-based assessment described in Neef and Lutz (2001b) to assess the impulsivity of students diagnosed with ADHD. Data indicated that for each participant immediacy of reinforcement was most influential. The intervention phase paired immediacy with a favorable aspect of another influential dimension before a delay fading procedure was implemented. Results indicated that previously impulsive participants tolerated reinforcement delays of up to 24 hours. Neef et. al., (2005) replicated and extended these results by comparing samples of students with and without ADHD. Data indicated that immediacy and quality were most influential for students with ADHD, and quality was most influential in the non-ADHD group.

Medication is increasingly being prescribed to treat students with ADHD. Neef, Bicard, Endo, Coury, and Aman (2005) examined the effects of medication on participants' response allocation to concurrent sets of math problems. In the double-blind,
placebo controlled study, participants' allocation patterns were not affected by the consumption of medication.

Neef and colleagues have demonstrated that time and response allocation can be differentially affected by altering reinforcer and response dimensions. The utility of interventions based on these assessment results has also been shown. Previous studies have shown reinforcer immediacy to be an influential dimension, especially in students diagnosed with ADHD (Neef, Bicard, & Endo, 2001; Neef, Bicard, Endo, Coury, & Aman 2005; Neef, et al., 2005). Therefore, the assessment of reinforcer dimensions was altered to examine the effects of temporal discounting toward delayed conditioned reinforcers and delayed terminal reinforcers. A limited amount of research has shown that interventions derived from an assessment of reinforcer dimensions can be effective in increasing academic related behaviors (Armstrong, 2002; Neef & Lutz, 2001a).

In order to replicate and extend the results of Neef and colleagues, (Mace, Neef, Shade, & Mauro 1994, 1996; Neef, Bicard, & Endo 2001; Neef, Bicard, Endo, Coury, & Aman, 2005; Neef & Lutz, 2001a, 2001b; Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994; Neef, et al., 2005), the present study examined the effectiveness of assessment based academic interventions. In Study 1 an assessment of dimensions of reinforcement was completed. This assessment pitted the dimensions of rate, quality, and response effort against immediacy. In Study 2 the results of the assessment were used to evaluate the effectiveness of interventions based on influential dimensions of reinforcement. Interventions were designed so the unfavorable
aspect of an influential dimension was paired with a favorable aspect of an equally or slightly less influential dimension.
CHAPTER 2: METHOD

STUDY 1: ASSESSMENT

Participants

Three students were selected for participation in this study based on teacher complaints of off-task behavior during independent seatwork times. All participants attended the same general education classroom and were in the 3rd grade. A teacher and aide were present in the split 2nd/3rd grade classroom. The class was made up of ten 3rd graders and thirteen 2nd graders. A school-wide token economy was in place. Each student had the opportunity to earn tokens for good behaviors. Tokens were delivered by teachers and other school personnel. Students could exchange their tokens for tangible items every two weeks. Within the classroom the teacher used a stoplight system. Each student began the day with a clip on the green light. When disruptive or off-task behavior occurred the teacher directed the student to move their clip to yellow. If disruptive or off-task behavior continued they were directed to move their clip to red. Consequences for moving down the stoplight system included teacher phone calls to parents, a trip to the principal’s office, missing recess, and being sent to P.E.A.K.

Joel was a 9-year-old Caucasian male. He was the only participant who had an Individualized Education Program (IEP) for Special Education services. He qualified for Special Education services in the area of Orthopedic Impairments. Joel participated fully in the general education classroom. He received occupational therapy services under his
IEP. Joel was diagnosed with Cerebral Palsy. Joel’s scores on the Metropolitan Achievement Test 8 indicated that he was performing in the Low Average norm groups. Joel exhibited persistent off-task behaviors and a low rate of accuracy on work completed during independent seatwork time.

Judah was an 8-year-old Hispanic/African-American male. No specific diagnostic information was available for Judah. He was receiving medication irregularly for ADHD. Judah’s scores on the Metropolitan Achievement Test 8 indicated that he was performing within the Average norm groups. Judah exhibited persistent off-task and disruptive behavior. He engaged in some occurrences of aggressive behavior towards peers.

Jeff was a 9-year-old Caucasian male. Jeff received medication for ADHD. Jeff’s scores on the Metropolitan Achievement Test 8 indicated that he was performing in the Average/Low Average norm groups. Jeff exhibited persistent off-task behavior and low rates of work completion during independent seatwork time.

Setting

Sessions were conducted outside of the regular classroom setting at various locations throughout the school. The three areas used included a tutor room; a stage that was adjacent to the library, but secluded from the main library by bookshelves; and a school counselor’s office. Each setting contained tables or desks with chairs, provided the participants with an area to operate a laptop computer and a mouse, and provided an area for unobtrusive data collection.

Assessment Apparatus
A computer program was designed to allow participants to complete math problems, similar to that used in Neef and Lutz (2001a/b). The assessment was conducted using a Dell Inspiron 3800 laptop computer with a conventional mouse and Microsoft Windows 98© operating system. The assessment provided two sets of problems that the participant could choose to work on. These sets (Set 1 and Set 2) could be independently manipulated by the experimenter.

The computer program was designed so the experimenter could manipulate several variables. These variables included session duration, choice time, inactivity time, rate of reinforcement, problem type, availability of reinforcement, type of reinforcement, and point status (Figure 2.1). During the assessment, points were assumed to be conditioned reinforcers that were exchangeable for tangible items following each session. Items that were available included grow-in-water animals, suckers, pencils, superballs, candy, Juicy Fruit gum, Garfield and Spiderman stickers, stretchy animals, and gum.

Session duration, choice time, and inactivity time affected both Set 1 and Set 2. The experimenter assigned values to rate, quality, immediacy and response effort for each problem set independently. Throughout the assessment the choice screen displayed Set 1 on the left in a white box and Set 2 was displayed on the right in a pink box.

The duration of each assessment session was 5 min. Choice time was programmed to 15 s to limit the length of time two problems were presented on the choice screen (Figure 2.2). If the selection of a problem was not completed within the choice time, two new problems were presented on the choice screen.
Figure 2.1. The computer program settings screen. From this screen the experimenter could manipulate all necessary variables.
Figure 2.2. Choice Screen. Elapsed time is indicated by the progress bar at the bottom of the screen.

Figure 2.3. Problem Screen. Elapsed time is indicated by the progress bar at the bottom of the screen.
Inactivity time was defined as the time a participant had to enter an answer from the problem screen (Figure 2.3). If the participant entered an incorrect answer, the same problem was shown on the problem screen and the inactivity time was restarted. If the participant did not enter an answer within the inactivity time the program reverted to the choice screen where the participant made another selection.

Rate of reinforcement was defined for each problem set independently on a VI schedule. This created a concurrent VI VI arrangement. The experimenter designated two values for each VI schedule. The first value was the average length of time in seconds before reinforcement was available on that set. The second value was the maximum length of time before reinforcement was available on that set. The high rate schedule was designated as VI 15/30. The moderate rate schedule was 30/45. The low rate schedule was 90/135. Time was applied to the reinforcement schedule for each set independently when the problem screen was up for that set.

Problem type could be manipulated by the experimenter through the selection of forty-one different mathematical tasks ranging from simple addition to division. The availability of reinforcement indicated when the terminal reinforcers would be delivered to the participant. The two options for this setting were today and tomorrow. If the availability was today, the reinforcer was selected and delivered at the conclusion of the 5 min experimental session. If the availability was tomorrow, the reinforcer was delivered the following day. Type of reinforcement was designated as store A or store B, and is described further in the preference assessment section. Point status allowed the experimenter to control whether points were displayed. If points were displayed then a
visual and an auditory cue was given upon point delivery; if points were hidden no visual or auditory cues were given upon delivery and a total was displayed at the end of the session.

**Dependent Measures**

The primary dependent measure was the percentage of responses allocated to concurrently presented sets of math problems. A response was defined as the selection of a problem from the choice screen by the clicking of a computer mouse or the entering of an answer on the problem screen.

**Data Collection and Measurement**

The computer program was set up to record response and time allocation; however, these data were not used because errors were discovered. A data sheet was developed which allowed the experimenter to record the participants' choices as well as correct or incorrect problem completion (Appendix A).

The number of problems completed correctly, incorrectly, and with no response was recorded for each set. If a problem was completed correctly a plus (+) was circled under the appropriate set. If a problem was completed incorrectly a minus (-) was circled under the appropriate set. If no response was made a slash (/) was written under the appropriate set.

**Interobserver Agreement**

Observers were two students in a graduate program in special education who had completed a course on research methodology. Observers were trained to 95% accuracy by the experimenter. Observers were trained to circle corrects, incorrects, and
nonresponses under Set 1 or Set 2. The computer program was briefly explained to the observers. The experimenter ran sessions selected using a general case strategy (Sprague & Horner, 1984). Each session contained a predetermined amount of corrects, incorrects, and timeouts that sampled the full range of responses the observer would be required to record.

Interobserver agreement (IOA) was calculated using a point-by-point agreement method (agreements divided by the sum of agreements plus disagreements, multiplied by 100). An agreement was defined as both observers scoring the same set as being selected on an individual trial. Agreement for Joel averaged 99.3% (range, 96% to 100%). Agreement for Jeff averaged 99.6% (range, 98% to 100%). IOA for Judah was 100%. Interobserver agreement for Joel, Jeff, and Judah was collected on 6 (27%), 5 (23%), and 4 (25%) sessions respectively. A total of two disagreements were recorded (821/823 or 99.8%). Over all participants IOA was collected on 25% of sessions (15/60).

Pretest

A pretest was conducted to determine high, moderate, and low effort problem types to be used during the subsequent assessment of reinforcer dimensions. The pretest included multiple 2-minute sessions using a variety of different types of math problems. During the pretest Set 1 and Set 2 were set up identically with respect to the dimensions of reinforcement. Results were combined from each set to give a total rate and accuracy measure.

Problem classes were defined as high/moderate/low effort based on rate and accuracy of problem completion during the 2-minute pretest. In order for a problem set to
be considered high effort for a participant, the results of the pretest needed to show
greater than 50% accuracy with a relatively low rate of completion. Moderate effort was
defined as greater than 75% accuracy with a higher rate of completion. Criteria for low
effort problem types were 95-100% accuracy with a higher rate of completion.

Joel's high effort problems were subtraction double digit minus single digit with
regrouping (4/6, 67%). Moderate effort problems were multiplication facts 1-6 (6/6,
100%). Low effort problems were addition facts with sums 0-18 (8/8, 100%).

Judah's high effort problems were division facts 1-9 (5/6, 83%). Moderate effort
problems were subtraction double digit minus single digit facts without regrouping (9/10,
90%). Low effort problems were multiplication facts 1-6 (15/15, 100%).

Jeff's high effort problems were three number-two column addition facts (4/7,
57%). Moderate effort problems were multiplication facts 1-6 (15/20, 75%). Low effort
problems were multiplication facts 1-3 (35/35, 100%).

Assessment Procedures

First, the participant completed a short preference assessment. Potential
reinforcers were written on small cards. These cards represented items the experimenter
had available for purchase using the points earned from completion of the session. The
participant placed the selected cards on a sheet of paper labeled as "Store A" or "Store
B." The participant was given the instruction: "Place five things you most want to earn
into Store __." If the session involved the manipulation of quality as a variable (Baseline
HQ v LQ or Q v I) the next instruction: "Of the items remaining, place the five you most
want to earn into Store __ (the opposite of the previously mentioned store)." If the
session did not involve the manipulation of the dimension of quality, the participant was given the instruction: “Place Store A and B together, either set of problems will lead to picking something out of the five selected items.”

After the participant had selected preferred items, the conditions of the session were explained by the experimenter. An explanation included information on the various settings operating within the session. Items explained to the participant included the time of delivery of the terminal reinforcer for each problem set, the store the student could select a reinforcer from for points earned in each problem set, and whether or not a practice session was to be conducted. A practice session was conducted for any session that had a high rate competing with a low rate on the opposite set. During the practice session the participant was instructed to complete problems only on Set 1 for two minutes. Then the experimenter would cue him to move to Set 2 for two minutes. For the final minute of the practice session the participant could choose to complete problems on either set. This was done to ensure the participant had contact with the differing rates of reinforcement.

After all variables were explained to the participant the experimenter asked the participant several questions to ensure adequate understanding of the contingencies. These questions included: “What set’s points can be used in Store A/B?” “What set’s points can be exchanged today/tomorrow?” These questions focused on the dimensions of quality and immediacy of exchange. The dimension of rate was covered when the participant completed the practice session. Response effort was evident upon the appearance of the choice screen when the session began.
Independent Variables and Assessment Conditions

A condensed description of assessment conditions is given in Figure 2.4. The Baseline condition was conducted to assess participants’ ability to discriminate between favorable and unfavorable aspects of a single dimension of reinforcement. Each baseline session involved the direct competition of relatively high and relatively low aspects of each dimension while all other dimensions remained consistent. The Baseline Effort session (HE v LE) included problem sets with equal rates of reinforcement, equal availability of reinforcement, and equal quality of reinforcers. The Baseline Quality session (HQ v LQ) included problem sets with equal rates of reinforcement, equal availability of reinforcement, and equal response effort. The Baseline Rate session (HR v LR) included problem sets with equal availability of reinforcement, equal quality of reinforcement, and equal response effort. The Baseline Immediacy session (Imm. v Delay) included problem sets with equal rates of reinforcement, equal quality reinforcers, and equal response effort. The Baseline condition assessed if participants would allocate responding according to favorable aspects of each dimension (e.g. high rate, high quality, immediate, and low effort).

The delay conditions allowed every other dimension of reinforcement (rate, quality, and response effort) to compete directly with immediacy. The two delay conditions were the Delay to Point condition and the Delay to Exchange condition. During each condition points were exchangeable for items selected in the preference assessment at a ratio of 4 to 1.
<table>
<thead>
<tr>
<th>Session</th>
<th>Baseline</th>
<th>Delay to Exchange</th>
<th>Delay to Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>HQ v. LQ</td>
<td>HQ v. LQ</td>
<td>HQ v. LQ</td>
</tr>
<tr>
<td>Rate</td>
<td>30/ 30/ 45/45</td>
<td>30/ 30/ 45/45</td>
<td>30/ 30/ 45/45</td>
</tr>
<tr>
<td>Effort</td>
<td>M M M M</td>
<td>M M M M</td>
<td>M M M M</td>
</tr>
<tr>
<td>Exchange</td>
<td>L H M M</td>
<td>I D M M</td>
<td>I D M M</td>
</tr>
<tr>
<td>Point</td>
<td>L H M M</td>
<td>I D M M</td>
<td>I D M M</td>
</tr>
</tbody>
</table>

Figure 2.4. Description of assessment conditions. HQ=High Quality, LQ=Low Quality, M=Moderate Effort, L=Low Effort, H=High Effort, I=Immediate, D=Delayed. Dimensions that competed within each session are highlighted.
The Delay to Point condition pitted each participant’s preference for the favorable aspects of rate, quality and response effort against the immediate delivery of the conditioned reinforcers, points. The Delay to Point condition tested each participant’s preference for the favorable aspects of other dimensions against the immediate delivery of points. The favorable aspects of rate, quality, and effort were paired with the delayed delivery of points. Those problem sets competed directly against immediate delivery of points paired with unfavorable aspects of a single dimension (rate, quality, or effort). Points were delivered with a visual and auditory cue. Delayed points were shown and recorded at the end of the five-minute experimental session.

The Delay to Exchange condition tested each participant’s preference for the favorable aspects of other dimensions against the immediate delivery of the terminal reinforcer. The favorable aspects of rate, quality, and effort were paired with a delayed reinforcer. Those problem sets competed directly against immediate reinforcement paired with the unfavorable aspects of a single dimension (rate, quality, and effort). Throughout the Delay to Exchange condition, immediate reinforcers were delivered at the end of the five-minute experimental session. Delayed reinforcers were accessed the next day.

Three sessions were conducted within each condition. The sessions were Rate versus Immediacy (RvI), Quality versus Immediacy (QvI), and Effort versus Immediacy (EvI). Two to four sessions were conducted per day.

In the QvI sessions, quality of reinforcement competed with either aspect of immediacy of reinforcement. High quality reinforcers, based on the preference assessment results, were available in one store (e.g. Store A), and other possible
reinforcers (low quality) were available in a second store (Store B). If Store A held the high quality reinforcers, then the delayed delivery of reinforcement (delayed points or delayed delivery of the tangible item) was paired with it. The low quality reinforcers were paired with the favorable dimensions of immediacy.

The RvI session involved the direct competition of rate of reinforcement and immediacy of reinforcement. During these sessions, one set delivered a high rate of reinforcement (VI 15/30) with the delayed aspect of immediacy. The opposing set delivered a low rate (VI 90/135) of reinforcement with the favorable aspect of immediacy.

The EvI session involved the direct competition of response effort and immediacy of reinforcement. During this session, high effort problems were paired with a favorable aspect of immediacy. Low effort problems were paired with the delayed reinforcers.

Baseline sessions were conducted once; Delay to Point and Delay to Exchange sessions were conducted at least twice. If a participant allocated a majority of responses to the favorable aspect of different dimensions within a condition, the session was repeated twice. The assignment of dimensions to Set 1 and Set 2 was counterbalanced over each condition.

*Experimental Design*

The three conditions were Baseline, Delay to Point, and Delay to Exchange. The experimental design was based on a model used for brief functional analyses (Cooper, et al., 1990). The pretest was given to determine current skill levels, followed by a Baseline condition and the experimental conditions. The experimental conditions were conducted
at least twice. Any session within each condition in which responses were not allocated to the same dimension was repeated two additional times.

Procedural Integrity

Procedural integrity was assessed using a 16 item checklist (Appendix B) on 27%, 25%, and 23% of the sessions for Joel, Judah, and Jeff. Analysis of completed procedural integrity checklists showed procedures were implemented with 100% integrity.

The experimenter conducted all observer training sessions. Observers were required to identify critical parts of the settings screen (Figure 2.1). Observers were also required to identify errors on the settings screen when given a data sheet (Figure 2.4) that included the required settings for the session.
CHAPTER 3: RESULTS

STUDY 1

Figures 3.1, 3.2, and 3.3 show the percentage of response allocation for Jeff, Joel, and Judah. During experimental conditions low effort is represented with a dotted bar, high quality with a white bar, high rate with a solid gray bar, and immediacy with a solid black bar. Sessions were conducted in randomized, counterbalanced order, but are shown in similar orders across participants to make interpretation easier.

Jeff

Jeff showed exclusive responding to a single set of problems during 21 of 22 sessions (95.5%). The second Delay to Exchange RvI session did not result in exclusive responding. Jeff selected one problem from the high rate set.

During the Delay to Exchange condition, Jeff allocated responding to the immediate reinforcer during 75% of sessions (6/8). When quality competed with immediacy, responding was allocated to high quality reinforcers during 67% of sessions (4/6). When rate competed with immediacy, responses were allocated to the set with the higher rate of reinforcement during 50% of sessions (3/6). When effort competed with immediacy, responses were allocated to low effort problems during 33% of sessions (2/6). During the Delay to Point condition responses were allocated to the set with immediate point delivery 30% of the time (3/10).
During the Delay to Exchange condition, Jeff allocated responses to sets that produced immediate reinforcement when they competed with effort and rate, but showed indifference when quality competed with immediacy. During the Delay to Point condition, Jeff showed indifference when effort competed with immediacy, and showed a preference for quality and rate.

Three sessions were repeated twice after initial results were inconclusive. These sessions were Delay to Point Evi, Rvi, and Delay to Exchange Qvi. Results for the Delay to Point Evi and for the Delay to Exchange Qvi sessions indicated indifference. Results of the Delay to Point Rvi session indicated rate of reinforcement was more influential than immediacy to points. Immediacy to exchange and quality were most influential for Jeff. Rate of reinforcement was the next, followed by response effort and immediacy to points.

The data for the Delay to Exchange Qvi sessions showed that Jeff allocated responding to both the high quality and the immediately delivered reinforcer on two of four sessions. Therefore, the experimenter was unable to determine which dimension (quality or immediacy to exchange) was more influential for Jeff.

Joel

Joel responded exclusively to one set of problems in 14 of 22 sessions (63.6%). Joel showed a strong preference (response allocation greater than 80%) for a single dimension in all other sessions following Baseline.

When quality and rate competed with immediacy, a majority of responses were allocated to the favorable aspects of those dimensions 83.3% of sessions (5/6).
effort competed with immediacy, responses were allocated to the low effort set 50% of sessions (3/6). During the Delay to Exchange Condition, responses were allocated to immediate delivery of reinforcement during 41.7% of sessions (5/12). Immediate point delivery was never influential. An analysis of the results without the Delay to Point condition revealed responding was allocated to the favorable aspects of quality and rate 75% of sessions (3/4), immediacy 41.7% of sessions (5/12), and low effort problems 25% of sessions (1/4).

During the Delay to Point Condition, responses were allocated to the alternative that produced delayed conditioned reinforcers and the favorable aspects of every other dimension. During the Delay to Exchange Condition, responses were allocated to the alternative that produced immediate reinforcement when effort competed with immediacy, but delayed reinforcers were chosen when quality and rate competed with immediacy.

Each Delay to Exchange session (Qvl, Rvl, Evl) was repeated twice after the initial results were inconclusive. Responses were allocated to high quality (Qvl), high rate (Rvl), and immediate delivery of reinforcement (Evl). Joel’s most influential dimensions of reinforcement were rate and quality, immediacy to exchange, response effort, and immediacy to points. Results did not provide a single most influential dimension because rate and quality never competed directly against each other. The data indicate rate and quality are equally influential.

Judah
Judah responded exclusively to one set in 14 of 16 sessions (87.5%). The two Delay to Exchange RvI sessions did not result in exclusive response allocation, however Judah allocated the majority of his responses (58.5% and 85.7%) to the set that produced the higher rate of reinforcement.

During the Delay to Point Condition, responses were allocated to the alternative that produced delayed reinforcement and contained the favorable aspects of every other dimension. During the Delay to Exchange Condition, responses were allocated to the alternative that produced immediate reinforcement when effort competed with immediacy, but responses were allocated delayed reinforcement when quality and rate competed with immediacy.

Judah's results indicate the dimensions of rate, quality, and response effort were more influential than immediacy to points. Therefore, the results summarized here omit the Delay to Point sessions. When quality and rate competed with immediacy, responding was allocated to favorable aspects of quality and rate during 100% of sessions (2/2). When effort competed with immediacy responses were allocated to the immediate delivery of reinforcement and high effort problems.

Judah's results indicated clear preferences. Responses were allocated to high quality and high rate of reinforcement sets during 100% of sessions. Quality and rate never competed directly against each other. Data indicated quality and rate were equally influential. However, Judah responded exclusively to the set that produced high quality reinforcement in the Delay to Exchange QvI session. In the Delay to Exchange RvI
session, responses were not allocated exclusively to the high rate set. These results indicate that quality was likely to be a more influential dimension than rate.
Figure 3.2. Percentage of Response Allocation- Joel
Figure 3.3. Percentage of Response Allocation- Judah
CHAPTER 4: METHOD

STUDY 2

Participants and Setting

Joel and Judah were selected for participation based on results from Study 1. Quality and rate of reinforcement were the most influential dimensions for both participants.

Sessions were conducted at a table located on one side of the general education classroom. The experimenter and participants were seated at the table. Sessions were conducted in the morning immediately following the participants’ reading group. On occasion, due to field trips, assemblies, etc., sessions were conducted in the afternoon immediately following the participants’ reading group. No more than two sessions per participant were run each day.

Influential Dimensions and Rationale for Intervention

The results of Study 1 showed that quality and rate of reinforcement were the most influential dimensions for Joel and Judah. In the general education classroom it is possible that undesirable behaviors operate on denser schedules of reinforcement than desirable behaviors. The goal of the intervention was to increase the participants’ tolerance for working on a lean schedule of reinforcement while maintaining high rate and accuracy of problem completion.
Rate was an influential dimension for both participants. Increasing the rate of reinforcement in the classroom often involves increased response effort on the part of the teacher. Solutions that require increased response effort often have lower social validity from those who implement them. Self monitoring interventions have proven to be widely accepted within school settings (Rosenbaum & Drabman, 1979). Another option would be to strengthen other dimensions that may compete successfully with rate. According to the assessment results, the dimension that would most likely compete with rate was quality. Therefore, quality and rate of reinforcement were manipulated so the participants would allocate more responses to a lean schedule of reinforcement.

Intervention Materials

Materials used included math worksheets, answer keys, a star stamp, timer, file folders, and tangible items to be used as potential reinforcers. Each participant completed two-digit times one-digit multiplication facts. Joel’s worksheets consisted of problems with the numerals 1-7. Judah’s worksheets consisted of problems with numerals 1-9. The math worksheets were designed with seven rows of eight problems each. Non-regrouping problems were interspersed every third problem.

Answer keys were identical to participants’ worksheets with the correct answers supplied by the experimenter. Stars were placed on the answer keys using a red star stamp. The stars were distributed according to the variable ratio schedule designated for the current phase. Stars represented points that were exchangeable at the end of the session for tangible items at a 4 to 1 ratio.
A folder system was designed to allow the participants to quickly determine if the answer was correct. The system also allowed for more immediate delivery of the conditioned reinforcers (stars). A file folder (9" x 11.75") was used. Windows (approximately .68" x .88") were cut in the top flap of the folder (seven rows of eight similar to the layout of problems on the worksheet). When the answer key was placed inside the folder, the math problems, answers, and stars appeared in the windows. Small strips of paper (approximately .38") were stapled between each row of windows on the inside of the front flap of the folder. These small strips were stapled to the folder horizontally. This allowed wider strips of paper (approximately 1.25") to be slid between the top flap of the folder and the smaller strips. The wide strips of paper could then be inserted and removed, and allowed the participant to reveal a single answer at a time. Tabs were placed on the ends of the strips to facilitate pulling the strips.

Preference Assessment

Prior to each experimental session, a preference assessment was completed. Participants were given a range of tangible items to choose from including: Blow pops, suckers, Juicy Fruit, gum, hard candy, stretchy animals, grow-in-water animals, superballs, airplanes, yo-yos, punch balls, jelly balls, pencils, jumping beans, and small toy cars. Participants were instructed to choose five items that they wanted to work for.

Data Collection and Interobserver Agreement

The dependent variable, rate of correct problem completion, was recorded by observing permanent products of participants’ work. Total rate and accuracy data were also collected. Rate of correct problem completion was calculated by dividing the number
of correctly completed problems by the length of the session (5 minutes). Total rate was calculated by dividing the total number of problems completed by the length of the session. Accuracy was calculated as a percentage, using the formula corrects divided by the sum of corrects and incorrects. Rate of correct problem completion was chosen as the dependent variable because it was most sensitive to changes in total performance. Total rate could have changed dramatically throughout the study without a measurable improvement in performance (i.e., the participant completes more problems but accuracy does not improve). The goal of the intervention was to increase participants' fluency defined as accuracy with speed. Rate of correct problem completion allowed the experimenter to adequately monitor participants’ progress and measure changes in mathematical performance.

Interobserver agreement (IOA) was conducted on at least 25% of sessions across each phase of the experiment. Joel: Baseline 25% (1/4), LR/HQ 33% (2/6), HR/HQ 29% (4/14), LR/HQ 25% (4/16) for a total of 28% of sessions (11/40). Judah: Baseline 25% (3/12), LR/HQ 29% (4/14), LR/LQ 29% (2/7), HR/HQ 25% (1/4) for a total of 27% (10/37). Observers were trained to evaluate the completed worksheets and mark problems as correct or incorrect to 100% criterion over 2 consecutive trials. Using a total agreement method (agreements divided by the sum of agreements and disagreements) IOA was 100% and 90% for Joel and Judah. Using a point-by-point agreement method IOA was 100% and 99.7% for Joel and Judah.

_Pretest/Posttest_
The experimenter and classroom teacher used the results from Study 1 as well as observation of participant performance on classroom tasks, to determine that two-digit times one-digit multiplication problems would be a significant class of problems to use for the intervention. The pretest and posttest were conducted with a worksheet of 63 two-digit times one-digit multiplication problems, aligned in seven rows of nine problems each. The participants were given five minutes to complete as much of the worksheet as possible. Upon the expiration of the five minute time period, students were instructed to place their pencils down and a score for rate of correct problem completion was calculated using an answer key.

The results of the pretest showed that a VR 6 schedule would be appropriate to use as a low rate of reinforcement. The experimenter determined it was the closest rate to that of the general education classroom that would allow participants to come into contact with the reinforcement contingencies.

**Baseline (A)**

Baseline was designed to replicate conditions in the participants’ general education classroom. Typically, students completed assignments and then received feedback after the teacher had graded the assignments and returned the worksheets to the students. In order to reduce the number of variables in the study, feedback was given at the end of the session rather than at a delay characteristic of the regular classroom.

Math worksheets were completed following the preference assessment. The experimenter calculated the number of points earned upon completion of the worksheets based on an answer key with stars distributed on a VR 6 schedule. The experimenter then
informed the participants of the number of points they earned and allowed them to exchange points for tangible items.

This phase was designed to be a low rate and high quality condition. Students were working towards the preferred items that had been selected immediately prior to the session. During this phase the participants completed the worksheets, the experimenter graded them, and points were delivered.

*Low Rate/High Quality “B” (LR/HQ)*

Both participants moved into the LR/HQ phase immediately following baseline. This phase was similar to baseline, except the folders containing the answer keys and star stamps were introduced. The participants completed the preference assessment before completing the worksheets. The conditioned reinforcers were placed on the math worksheets on a VR 6 schedule.

*High Rate/High Quality “C” (HR/HQ)*

During this phase the rate of reinforcement was changed to a VR 3. Participants worked for high quality reinforcers. All other procedures remained identical to those described in LR/HQ.

*Low Rate/Low Quality “D” (LR/LQ)*

During this phase Judah worked for low preference items. To determine Judah’s low preference items, the experimenter analyzed what items Judah had selected during previous preference assessments. Of the 15 items available for selection, Judah had never selected five (in 18 opportunities). It was determined that these items were lower quality
than those available in Baseline and LR/HQ. The items available for selection included stretchy animals, grow in water animals, Juicy Fruit, candy, and gum.

Additional Notes

During session #43 the experimenter observed Judah uncovering answers from the folder system/answer key before he entered an answer on his math worksheet. Further observation of his worksheet indicated that it was likely he had cheated. The last four correct answers to the first line of problems were 84, 84, 272, and 105. Judah’s answers read 84, 272, 105, 105, indicating that he had skipped the second 84 when copying answers. The experimenter determined that it was likely that Judah had been doing this for some time over the course of the study, but up to this point had been undetected.

To decrease the probability of this occurring again, and to make the occurrence more easily detectable by the experimenter, several changes to experimental procedures were implemented. The experimenter had been monitoring both participants concurrently; during the remaining four sessions of the study the participants completed their worksheets at separate times and were independently observed by the experimenter. Since Judah’s behavior was covert, the experimenter also decided to insert one incorrect answer on each line of the answer key to make any cheating more easily detectable.

Experimental Design

The experimental design used for Joel was an ABCB reversal design. The design used for Judah was an ABDC design. Each participant reacted uniquely to the LR/HQ phase, so a multiple baseline design across participants was abandoned.
Joel's data indicated it was possible he would respond to a higher rate of reinforcement, so he proceeded to the HR/HQ phase. This phase showed an increase in the number of problems completed correctly per minute (see Chapter 5, Results for further discussion of the data), a reversal to LR/HQ was implemented. This was done in an attempt by the experimenter to show experimental control.

Judah responded differently to the contingencies in the LR/HQ phase and had already shown an increase in the number of problems completed correctly per minute. Therefore, LR/LQ was implemented. It was during this phase that Judah was observed not following experimental procedures. Upon that discovery it was determined that Judah would move to the HR/HQ phase since his increased rate of correct problem completion had been artificially inflated.
CHAPTER 5: RESULTS

STUDY 2

Rate of Correct Problem Completion

Figures 5.1 and 5.2 show the number of problems completed correctly per minute for Joel and Judah. Rate of correct problem completion was measured across four phases. Judah’s rate of correct problem completion averaged 4.25 during baseline (range, 1.8 to 6.4), 5.69 during LR/HQ (range, 3.2 to 8.4), 8.31 during LR/LQ (range, 4.8 to 11.0), and 6.3 during HR/HQ (range, 4.6 to 8.0). Joel’s rate of correct problem completion averaged 2.80 during baseline (range, 1.4 to 4.2), 2.33 during LR/HQ (range, 1.6 to 2.6), 3.49 during HR/HQ (range, 1.6 to 4.8), 5.76 during LR/LQ (range, 3.6 to 7.2).

Summary

Judah’s results from the pretest (4/25/05) showed a rate of correct problem completion of 1.4 with 44% (7/16) accuracy. On a similar post-test, Judah’s rate of correct problem completion was 15.2 and his accuracy increased to 85.7% (6/8/05). Results from the pretest showed Joel (4/21/05) had a rate of correct problem completion of 2.8 with 50% (14/28) accuracy. The post-test (6/8/05) showed Joel’s rate of correct problem completion was 9.4 and his accuracy had increased to 78.3%.
Figure 5.1. Number of Problems Correct per Minute-Joel
Figure 5.2. Number of Problems Correct per Minute-Judah. The open circle represents any session with a rate of problem completion above 7.0 and accuracy over 87.5%. Session 43 is indicated by an open triangle, when Judah was observed not following experimental procedures.
CHAPTER 6

DISCUSSION

Results from Study 1 indicated the alteration of the dimensions of reinforcement on two concurrent response options resulted in a preference of one response alternative over the other. Response allocation was nearly exclusive to the option associated with the preferred dimension. Data indicated preferred dimensions were idiosyncratic.

The results of Study 1 indicated the computer-based assessment of reinforcer dimensions identified student preference for particular dimensions. The results of this study replicated the findings of Neef and colleagues (Mace, Neef, Shade, & Mauro, 1996; Neef, Bicard, & Endo, 2001; Neef, Bicard, Endo, Coury, & Aman, 2005; Neef & Lutz, 2001a/b; Neef, Shade, & Miller, 1994; Neef et al., 2005).

In Study 2 the results of the assessment were applied to develop interventions to increase academic responding. Joel’s results from Study 2 indicated his behavior may have been influenced by rate of reinforcement. This is consistent with the prediction of the assessment completed in Study 1. Joel’s rate of correct problem completion did not begin to increase until the rate of reinforcement increased in the HR/HQ phase. Judah’s results from Study 2 indicated his rate of correct problem completion was not affected by rate of reinforcement. Data for Judah must be interpreted cautiously as he did not follow experimental procedures during session 43. Upon the discovery that Judah had not followed experimental procedures, several changes were instituted to ensure that Judah
did not deviate from procedures again. These procedures included a transition to one-to-one sessions and interspersal of incorrect answers on the answer sheet.

Limitations and Suggestions for Future Research

One limitation of the study was the small sample size and the unreliable data regarding the participants' use of medication prescribed for ADHD. Neef, Bicard, Endo, Coury, and Aman (2005) demonstrated that medication did not affect participants' response allocation on concurrent schedules with differing dimensions of reinforcement. Future research should repeat the current study with a larger group of students whose specific diagnostic and medication information is available.

In addition, neither study conducted a parametric analysis of the dimensions of reinforcement. Influential dimensions could be made more or less influential by changing the relative value of each dimension. The current assessment compared preferences for rate, quality, response effort, and immediacy at consistent values. Each of these dimensions exists on a continuum in the applied setting and is not always set at a consistent value. For example, rate of reinforcement may be considered influential when VI 15/30, VI 90/135 schedules are pitted against each other, however, VI 15/30 and VI 60/90 schedules may lead to different results. Future research should focus on conducting a parametric analysis of the dimensions of reinforcement to determine if there are levels particular to each dimension that would cause a change in response allocation. For example assume a participant for whom effort is most influential and rate is least influential. At what level of rate and effort will responding be allocated to the high effort, high rate problem set? Also, data for each participant indicated the immediacy to the
exchange for the terminal reinforcer was more influential than the immediacy to the conditioned reinforcers. This could also be the subject of a parametric analysis to determine at what relative values immediacy to conditioned reinforcers becomes more influential. In order to conduct a parametric analysis, influential dimensions must be determined. Then differing values of the most influential dimension could be pitted against another constant dimension. For example, assume a participant’s most influential dimension of reinforcement is rate. Rate was assessed at two values (15/30 and 90/135) and competed with immediacy. An experimenter could evaluate the preference for high rates by lowering the rate (to 30/45, 60/90, etc.) and evaluating the affects on response allocation, rate, and accuracy of problem completion.

Another limitation is that time allocation was not assessed as a dependent variable. Myerson and Hale (1984) cited several studies (Baum & Rachlin, 1969; Brownstein & Pliskoff, 1968; Myerson & Miezin, 1980; Rachlin, 1978) that suggested time allocation was a more relevant dependent variable than response allocation. Although the absence of time allocation data is a limitation, it should be noted that for the participants involved in this study, responding was exclusive or nearly exclusive to one set of problems. Time allocation would have likely mirrored the results yielded by response allocation. However, this may not be true for all future participants. Time allocation becomes most useful when considering a student who allocates responding to high effort problems that require more time to complete, thereby resulting in a lower number of problems completed. If the student does not respond exclusively to the high
effort set, then the response allocation data could differ significantly from time allocation data.

In the current investigation, the assessment did not include direct competition of all dimensions of reinforcement. Both rate and quality were equally influential for Joel and Judah. Quality versus rate, quality versus effort, and rate versus effort sessions could have been conducted on an as needed basis to determine which of the two dimensions was more preferred. However, these additional data may not lead to any new information if the student allocates responding as Jeff did in the Delay to Exchange QVI sessions. Jeff responded exclusively to one set during each session, but favored different dimensions. This illustrates the hypothesis that participant's preferences may change over time, or be affected by motivating operations the experimenter was unaware of. One area that could be studied further is how a participant's history of reinforcement affects response allocation (Lattal & Neef, 1996).

A relevant point of discussion involves the method the computer system used to calculate and record the variable interval schedules responsible for the availability and delivery of the conditioned reinforcers. Matching law indicates that on concurrent schedules, the participant will allocate responding in such a way as to maximize reinforcement. Dependent upon what type of concurrent schedules are in place, there will be different patterns of responding. On a concurrent VR/VR arrangement, with all other dimensions being equal, it is likely that the subject will respond exclusively to the richer schedule of reinforcement (Fisher & Mazur, 1997). McDowell (1988) states: “In the typical concurrent VI VI schedule, both component VI schedules operate (i.e., the timing
of their intervals continues) regardless of what the pigeon [participant] is doing." (97). To maximize reinforcement on concurrent VI/VI schedules, the subject would have to switch between response options.

The current study used concurrent VI/VI schedules of 15, 30, and 90. Time was only credited to each schedule when that problem set was displayed on the problem screen. This set up a schedule of reinforcement that was based on time, but had the characteristics of a variable ratio schedule. In a concurrent VI/VI arrangement, time would be credited to each schedule regardless of what problem set was currently being worked on. This most likely led to results that indicated clearer preferences for particular dimensions by promoting exclusive responding to a single set of problems.

A limitation of applied significance for both Study 1 and Study 2 was that tangible items were used throughout the intervention. This presumably had an effect on participants’ behaviors, as each participant was referred for exhibiting off-task behaviors, but during the experimental sessions no off-task behavior was noted. Often, tangible items are not used in general education classrooms for a variety of reasons. The extra demands placed on teachers, cost, and a belief that students should work for a “love of learning” all contribute to a lack of tangibles (and at times a lack of reinforcement) in the classroom. For this study tangibles were used because the dimension of quality could be more objectively and readily controlled. Further research may focus on reinforcers of different types (i.e., praise statements, grades, etc.) to determine if qualitative differences exist and if those differences affect behavior.
Experimenters were unable to demonstrate experimental control in Study 2. Joel and Judah reacted differently to the LR/HQ phase. Joel’s performance remained around 2.4 correct problems per minute throughout this phase. Judah’s performance increased from 3.2 correct problems per minute to 8.4 correct problems per minute and appeared to be steadily increasing. As a result, Joel was moved to the HR/HQ phase. Judah progressed to a LR/LQ phase. This eliminated the symmetry necessary to show experimental control between participants. Joel’s performance began to steadily increase in the HR/HQ phase.

When Joel moved from the LR/HQ phase to the HR/HQ phase, the only change was the VR schedule. Because the VR schedule controlled the availability of the conditioned reinforcers (points), a certain performance level had to be reached before the participants would have an adequate number of points to exchange for a tangible item. During Baseline and LR/HQ, Joel’s performance never reached that point. Joel did not receive enough points to access the terminal reinforcer (tangible item) until session 17. The results from session 17 show that Joel had a rate of correct problem completion of 1.8. He had exceeded that mark in 8 of 11 previous sessions, yet had never earned enough points to access the terminal reinforcer because he had missed the starred problems. Joel’s behavior prior to session 17 indicated that participants may have a specific tolerance for receiving or not receiving reinforcement. Future research is necessary to determine how participants perceive their chances of earning reinforcement, and to determine if a percentile schedule of reinforcement could adequately capture a tolerance for reinforcement for tasks of a given response effort.
It could not be determined whether the change in Joel’s rate of correct problem completion was due to the increased rate of conditioned reinforcers or the delivery of the terminal reinforcer. Prior to session 17, Joel made several comments that showed frustration at not earning enough points (e.g. “Do I have to do this?”; “Can we just do one worksheet today?”). The increased rate of reinforcement did make it more likely that he would earn the terminal reinforcer by the placement of more stars on the page. Joel’s rate of correct problem completion did change in the HR/HQ phase. However, it is unclear whether this change was caused by the increased rate of reinforcement or by increased access to the terminal reinforcer.

Judah’s performance increased in Baseline before leveling off. His performance also increased in LR/HQ. This increase occurred despite a relatively low rate of reinforcement (VR 6). This eliminated the option of using a multiple-baseline design across participants to show experimental control.

Finally, Judah’s performance during intervention must be interpreted cautiously as he deviated from the experimental procedures. The experimenter could not determine precisely when Judah began to deviate from the experimental procedures. It was hypothesized that this occurred when Judah had a rate of problem completion greater than 7.0 and his accuracy was greater than 87.5%. This occurred during the following sessions: 29, 35-39, 42, 43. Additional procedures were implemented at session 44 to ensure that no further cheating occurred. The experimenter believes the above data were likely to be the only compromised data, but it is possible Judah cheated during other portions of the study. This behavior went undetected by the experimenter because the
behavior was covert, the experimenter was monitoring two participants simultaneously, and little response effort was required to cheat. The additional procedures eliminated Judah’s cheating behavior for the final five sessions. In the future it would be beneficial if correspondence training procedures (Karlan & Rusch, 1982; Israel, 1978) were used to reduce the probability of this behavior occurring.

Students master skills after going through several stages of learning. The skill measured throughout the study was the participants’ completion of two-digit times one-digit multiplication facts. The pretest showed this skill to be at about 50% accuracy with low rates of completion. These results show that the participants had not mastered the skill, and it was still in the acquisition stage of learning. Joel’s results may provide a prime example of a student who does not show improvement in the acquisition stage until the dimensions of reinforcement are favorable to his preferences, but once the skill is acquired participants may be more tolerant of reinforcers that have not been optimized to their preferences. This conclusion is weakened by the fact that Joel never earned the reinforcer before the dimensions were changed to be favorable to his preferences. More research is necessary to determine if manipulations of the dimensions of reinforcement show greater effects for skills in the acquisition, practice, or independent stages of learning.

In addition, more research is needed to identify interventions that are most effective for students who share an influential dimension of reinforcement. If it is found that students with particular influential dimensions respond significantly better to certain interventions, then the assessment could be used as a direct link to providing effective
Interventions on an individualized basis. Similar research could also identify interventions that are effective for students with differing assessment profiles.

**Implications for Practice**

An assessment of dimensions of reinforcement is beneficial to a practitioner when it informs intervention procedures. Munk and Repp (1994) reviewed instructional variables which have an effect on problem behavior. The variables they discussed included: student choice of task, task variation, pace of instruction, interspersal of high-probability tasks, partial versus whole task, and reducing task difficulty/errors. Several of those variables are directly connected to the alteration of particular dimensions of reinforcement.

Student choice of task can be viewed as an altered dimension of reinforcement. Choice and the perceived independence it brings may provide the antecedent to a feeling of control, which would be a qualitatively different reinforcer than previously available. Students are likely to choose tasks that are easier for them to complete, decreasing response effort and increasing the rate of reinforcement for task completion (Belfiore, Lee, Vargas, & Skinner, 1997).

Task variation could also be looked at as an adjustment in rate of reinforcement. Several studies have examined the relationship of alternating acquisition and mastered tasks (e.g., Winterling, Dunlap, & O’Neill, 1987; Dunlap, 1984). The findings of these studies indicate that when a new skill is alternated with several mastered skills, the skill will be acquired sooner and will be emitted with lower rates of problem behavior.
Pace of instruction and interspersal of high-probability tasks vary the rate of reinforcement. Faster paced instruction will lead to increased opportunities for reinforcement while also increasing the benefit of paying attention to the instruction. High-probability tasks are more likely to lead to reinforcement. When these tasks are interspersed throughout instruction, students will be more likely to continue completing tasks (Belfiore, Lee, Vargas, & Skinner, 1997; Billington, Skinner, & Cruchon, 2004; Neef, Iwata, & Page, 1977; Skinner, Hurst, Teeple, & Meadows, 2002).

Partial versus whole task and reduction of task difficulty or errors are two procedures that are very similar in that they increase the probability that the student will come into contact with reinforcement by modifying the response effort required. Taken together, these studies and others illustrate that effective interventions often alter some dimension of reinforcement.

This study contributes to the development of more effective interventions. The intervention package was deliberately designed to manipulate the rate and quality of reinforcement through the use of a self-monitoring intervention. There were also several other favorable instructional practices included in the intervention, including immediate feedback, immediate delivery of points, and immediate delivery of the terminal reinforcer. Additional research is necessary to determine if favorable aspects of influential dimensions alone can lead to an effective intervention package.

A conceptual understanding of how the dimensions of reinforcement function is beneficial to the applied behavior analyst. When a potential reinforcer is available, yet is not functioning as a reinforcer, the behavior analyst may be able to analyze the
dimensions of reinforcement to determine what changes should be made. A systematic study of an individual’s preferences for particular dimensions of reinforcement is most likely to be beneficial to a behavior analyst who is providing for the availability of reinforcement, yet is not producing behavior change. When influential dimensions can be determined, those dimensions can be strengthened on the desirable response option.

Summary

Although far from conclusive, the results of these studies indicated that it is possible to determine what dimensions of reinforcement are most influential for an individual. While additional research is necessary, the results also indicated that interventions based on increasing the relative strength of influential dimensions will be effective at increasing academic behaviors.
LIST OF REFERENCES


APPENDIX A

STUDY 1 DATA SHEET
**Delay to Exchange and Delay to Point Delivery Data Sheet**

<table>
<thead>
<tr>
<th>Observer</th>
<th>Session</th>
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<tbody>
<tr>
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<td>Condition</td>
</tr>
<tr>
<td>Experimenter</td>
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### Preference Assessment

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### Task Parameters

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#### Session Data Summary

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APPENDIX B

PROCEDURAL INTEGRITY CHECKLIST
## PROCEDURAL INTEGRITY CHECKLIST

<table>
<thead>
<tr>
<th>Observer</th>
<th>Date</th>
<th>Participant</th>
<th>Session</th>
<th>Experimenter</th>
<th>Condition</th>
</tr>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

1. Experimenter sets computer to appropriate assessment dimensions  
2. Experimenter sets length of session at 5 minutes  
3. Experimenter sets duration of choice time at 15 seconds  
4. Experimenter sets duration of inactivity time at 30 seconds  
5. Experimenter sets appropriate type of math problems  
6. Experimenter sets appropriate level of math problems  
7. Experimenter sets appropriate schedule of reinforcement  
8. Experimenter sets appropriate availability of reinforcement for each store  
9. Experimenter sets appropriate delivery of reinforcement  
10. Experimenter sets computer to appropriate point-showing setting  
11. Experimenter randomizes assignment of dimensions to set one and set two  
12. Experimenter conducts practice session with points showing  
13. Experimenter conducts brief preference assessment  
14. Experimenter conducts experimental session  
15. Experimenter allows participant to work independently  
16. Experimenter awards prize or receipt as appropriate at end of session  

- Check the Yes box if observed  
- Check the No box if not observed  
- Write NA if it is not applicable