8-2003

Varying problem effort and problem completion rates : an investigation of the interspersal procedure and student assignment choice

Eric J. Billington

To the Graduate Council:

I am submitting herewith a dissertation written by Eric J. Billington entitled "Varying problem effort and problem completion rates : an investigation of the interspersal procedure and student assignment choice." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Christopher Skinner, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Eric J. Billington entitled "Varying Problem Effort and Problem Completion Rates: An Investigation of the Interspersal Procedure and Student Assignment Choice." I have examined the final paper copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Christopher Skinner, Major Professor

We have read this dissertation and recommend its acceptance:

John Malone

Richard Saudargas

Robert Wahler

Accepted for the Council:

Vice Provost and Dean of Graduate Studies

VARYING PROBLEM EFFORT AND PROBLEM COMPLETION RATES: AN INVESTIGATION OF THE INTERSPERSAL PROCEDURE AND STUDENT ASSIGNMENT CHOICE

A Dissertation Presented

For the Doctor of Philosophy Degree

The University of Tennessee, Knoxville

Eric J. Billington

August 2003

Abstract

The discrete task completion hypothesis suggests that, when given assignments comprised of multiple discrete tasks, completed discrete tasks are reinforcing events (Skinner, 2002). The current experiment consists of two studies investigating the interaction of relative response effort and relative problem completion rates on student assignment choice and ranking behavior. College students participated in Experiment One. In order to enhance the educational validity of the findings from Experiment One, Experiment Two was conducted with sixth-grade students.

In Experiment One, college students were exposed to two pairs of mathematics assignments. Assignment Pair A included a high effort assignment containing 18 long 3-digit x 2-digit multiplication problems with all numerals in each problem being equal to or greater than four and a moderate effort assignment that contained nine long problems and nine interspersed moderate 3-digit x 2-digit problems with numerals less than four. Assignment Pair B contained similar assignment sheets, the exception being that the high effort assignment contained six additional 1-digit x 1-digit problems interspersed following every third 3-digit x 2-digit problem. Analysis of Assignment Set One revealed that students overwhelmingly preferred the moderate effort assignment. Analysis of interaction effects showed that when additional brief problems were added to the high effort assignments, the proportion of students who chose the high effort assignment for homework and ranked it as being less difficult, time consuming, and effortful increased significantly. Results support previous research on effort and the hypothesis that a completed discrete problem may serve as a reinforcing event.

Experiment Two was a replication of Experiment One. However, the educational validity was enhanced, as participants were sixth-grade students who were exposed to assignment pairs identical to those of Experiment One. Results were similar to those found in Experiment One.

Results from both experiments showed that students were more likely to choose assignments that required less effort to complete. However, when high effort assignments were altered by interspersing additional brief problems, the probability of students choosing the high effort assignment for homework increased significantly. These results support the discrete task completion hypothesis and suggest that educators can increase the probability of student engaging in assigned work by giving them more work. Additionally, logistic regression analysis yielded models of choice behavior similar to those found in previous studies of the matching law (e.g., Baum, 1974). This novel analysis of group data provided additional support for the discrete task completion hypothesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure	**Page**

CHAPTER I

INTRODUCTION

After students have acquired skills, educators often assign independent seatwork to help students develop skills (Haring & Eaton, 1978). After assigning independent seatwork, students may choose to engage in assigned tasks or in numerous alternative behaviors. When students choose to engage in assigned tasks, increases in skill accuracy, fluency, and maintenance are likely to occur (Binder, 1996: Greenwood, Delquadri, & Hall, 1984). However, when students choose to engage in other behaviors, skill development is likely to suffer and they may be more likely to choose to engage in disruptive behavior (Coleman, 1970; Dunlap & Kern, 1996). Thus, basic research on choice behavior and specific procedures that can be used to alter student choice behavior may allow educators to prevent academic and behavior problems.

Basic research and theory suggests that when given the choice of two behaviors and all else is held constant, organisms are more likely to engage in the behavior that requires the less amount of effort (Aparicio, 2001; Billington & Skinner, 2002). Researchers investigating assignment alteration procedures have found that this basic theory applies to student behavior. Specifically, researchers have decreased the time and effort required to complete assignments by substituting previously learned material in place of new material or shortening assignment length (Cooke, Guzaukas, Pressley, & Kerr, 1993; Winterling, Dunlap, & O'Neill, 1987). Results have shown that such procedures can enhance students' perceptions of assignments, increase the probability of students choosing to engage in assigned tasks, and decrease the probability of students choosing to engage in inappropriate behaviors.

While altering assignments in this manner may increase the probability of students engaging in such tasks, learning may be impaired when students choose or are assigned briefer or easier assignments (Roberts & Shapiro, 1996; Roberts, Turco, & Shapiro, 1991). However, if educators can design assignments that students prefer, without reducing educational demands, skill development may be enhanced and inappropriate behaviors may be decreased (Skinner, Fletcher, & Hennington, 1996).

Researchers applying Herrnstein's (1961) matching law have identified several variables that can be used to increase the probability of students choosing to engage in assignments that do not require reducing assignment demands. Researchers have shown that enhanced rate, quality, and immediacy of reinforcement for engaging in assignments will increase the probability of students engaging in assigned work (e.g., Martens & Houk, 1989; Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994). In some studies, teacher attention served as the reinforcer (e.g., Martens & Houk, 1989). Other researchers manipulated tangible reinforcers including edible reinforcers and tokens (e.g., Mace, McCurdy, & Quigely, 1990; Neef et al., 1994). One applied concern with such procedures is that educators may have difficulty monitoring each student's academic behavior and enhancing reinforcement quality, rates, and immediacy contingent upon each academic response.

Recently, researchers have developed a theory (the discrete task completion hypothesis) and procedure (interspersal procedure) that may allow educators to efficiently enhance rates of reinforcement for student academic behavior (Skinner, 2002). The discrete task completion hypothesis states that when working on assignments composed of multiple discrete tasks, a completed discrete task is a reinforcing event. This theory is based on an assumption regarding students' learning histories and classical conditioning. Specifically, it is assumed that students have a learning history where assignment completion has been reinforced. Stimuli that reliably precede this reinforcement are the completed discrete tasks that comprise assignments. Research on classical conditioning suggests that this learning history should cause a completed discrete task to become a conditioned reinforcer (see Skinner, 2002). If this theory is accurate, enhancing discrete task completion rates, enhances rates of reinforcement for engaging in assigned work and should increase the probability of students choosing to engage in assigned tasks.

Studies using the interspersal procedure have supported this theory. In these studies, researchers have enhanced discrete task completion rates by interspersing *additional* brief tasks. Thus, rather than decreasing assignment demands, researchers have actually increased demands associated with assignments. For example, Skinner et al., (1996), instructed students to work two mathematics assignments for equal amounts of time. The control assignment contained 16 three-digit by two-digit (3x2) multiplication problems while the experimental assignment contained 16 similar problems as well as six one-digit by one-digit (1x1) multiplication problems interspersed after every third 3x2 problem. Results showed that discrete task completion rates were higher on the experimental assignment and after working on both assignments, significantly more students indicated that the control assignment was more difficult and would require more time and effort to complete. Students were then asked to choose an assignment for homework. Results showed that significantly more students chose a new experimental assignment for homework.

In many interspersal studies, students (e.g., Skinner et al., 1996; Skinner et al., 1999) not only chose assignments associated with higher task completion rates, but also chose assignments requiring more effort to complete (i.e., target problems plus the brief interspersed problems). However, it could be argued that the brief interspersed problems were so brief that they required an insignificant amount of effort to complete. Also, the interspersed problems may have had little instructional value. While interspersing additional brief and easy tasks seems to be an efficient procedure for enhancing assignment perceptions and choice when assignments contain an equal number of target problems, what would be of greater educational value is to influence students to choose assignments that require them to complete assignments containing more educationally valid target tasks (Cates & Skinner, 2000).

CHAPTER II

REVIEW OF LITERATURE

The current literature review will first address why student choice is critical for preventing and remedying behavior and learning problems. Next, variables that influence choice behavior will be reviewed. Difficulties with implementing these findings in classroom settings will be discussed, followed by recent research that suggests procedures that may address these limitations. Finally, this research will be summarized and the purpose of the current experiments will be described.

The Issue of Student Choice

Choice is an always-present aspect of education. Students can either choose to engage or not engage in academic tasks. Increasing the likelihood of students choosing to engage in assigned academic tasks can both enhance learning rates and decrease inappropriate classroom behavior (McCurdy, Skinner, Grantham, Watson, & Hindman, 2001). While instructors may assign tasks such as seatwork, students choose whether or not to engage in assigned tasks (Skinner, Robinson, Johns, Logan, & Belfiore, 1996). Increasing the likelihood of students engaging in academic tasks can both enhance learning rates and decrease inappropriate classroom behavior (Dunlap & Kern, 1996; McCurdy et al., 2001; Skinner, Wallace, & Neddenreip, 2002).

Often, educators have focused on classroom order rather than mastery of academic skills (Coleman, 1970; O'Leary, Becker, Evans, & Saudargas, 1969; Silberman, 1970; Thomas, Becker and Armstrong, 1968; Winnet & Winkler, 1972). Researchers have indicated a variety of behaviors designated as appropriate and inappropriate. Inappropriate behaviors include behaviors such as the student being out of his/her seat, moving around, or talking. Appropriate behaviors include attending to the teacher, raising hands and waiting for the teacher to respond, and quietly working on seatwork. While silence and lack of movement may be necessary for teachers to maintain an orderly classroom, students may find such requirements undesirable. If researchers can find ways to make educational tasks more acceptable, students will be more likely to choose to engage in those behaviors. As the matching law predicts, when a certain behavior (academics) increases (occurs more frequently), competing behaviors (inappropriate classroom behaviors) will decrease (Coleman, 1970; Skinner et al., 1996). Not only will the inappropriate behaviors decrease when students choose to engage in academics, but the resulting increases in academic behavior can result in enhanced learning rates and skill mastery (McCurdy et al., 2001; Binder, 1996; Greenwood et al., 1984; Haring & Eaton, 1978). Thus, research investigating student choice is critical.

The Matching Law and Education

Herrnstein's (1961) matching law has proven to be an effective method of exploring the factors affecting student choice and identifying underlying mechanisms that influence choice behavior. Researchers have used the matching law to investigate student choice behavior and develop strategies and procedures that educators can use to increase the probability of students choosing to engage in assigned academic tasks (e.g., Cates & Skinner, 2000; Skinner, Fletcher, & Hennington, 1996). The matching law states that given a choice of behaviors, relative rate of responding will match (be equal to) the relative rate of reinforcement. The simplest expression is termed the strict matching equation and is symbolically represented as:

$$\frac{R_1}{R_1+R_2} = \frac{r_1}{r_1+r_2} \qquad \text{(Equation 1)}$$

where R represents the respective rate of responding and r represents the respective rate of reinforcement (Davison & McCarthy, 1988). Other researchers have noted that time allocation may also be used to express rate of responding for choice alternatives (Baum & Rachlin, 1969; Rachlin, 1978). Since educational activities may require different amounts of time to complete (e.g., some tasks are more difficult than others), counting tasks (e.g., mathematics problems, spelling words, sentences) completed per unit of time may not allow for precise prediction and measures of time allocated to assignments may be more valid measures of choice behavior.

In its simplest form, the matching law states that when all else is held constant and two choices are provided, the relative rates of responding will match (i.e., be equal to) the relative rates of reinforcement for those behaviors. For example, in a two choice situation where 66% of the available reinforcement can be obtained from one choice and 34% of available reinforcement can be obtained from an alternative choice, the matching law would predict that 66% of the total responding would be allocated to the first alternative. Myerson and Hale (1984) described theoretical applications of the matching law across various types of competing reinforcement schedules in educational settings. Billington and DiTommaso (2003) describe a series of studies that supports Myerson and Hale's (1984) conceptual work.

Billington and DiTommaso (2003) demonstrate relevance of the strict matching equation and outline studies where varying reinforcement rates for educational activities follow predictions of the matching law. For example, Mace, McCurdy, and Quigley (1990) demonstrated systematic shifts in preference with changes in relative rates of reinforcement in a 16 year-old high-school student on academic tasks. The student was allowed to choose math problems from two different stacks of math cards containing multiplication and division problems. The researchers demonstrated that time spent responding on either stack of cards varied with the relative rates of reinforcement for either stack of cards.

The above example relies on all available reinforcement being accounted for and under the control of the experimenter. However, this type of control is difficult to obtain in educational settings. All behaviors compete for reinforcement and many times control of these variables are outside the control of the educator or experimenter (Herrnstein, 1974; Myerson & Hale, 1984). However, the effects of such outside reinforcement can also be assessed with the matching law. Fluctuations in response rates for single target behaviors have been predicted based on changes in available reinforcement for other naturally occurring behaviors (de Villiers & Herrnstein, 1976; Herrnstein, 1970; Herrnstein, 1974). Researchers in these studies have demonstrated that behavior for the target response will vary with the amount of extraneous reinforcement competing against the target response.

While Myerson and Hale (1984) discussed theoretical applications of the strict matching equation, Billington and DiTommaso (2003) discussed the relevance of other matching equations. Accurate prediction with the strict matching equation relies on all available reinforcement being accounted for and under the control of the experimenter. However, this type of control usually can occur only in experimental settings. The effects of such outside reinforcement can be assessed by a derivation of the strict matching equation known as the single alternative hyperbola, or Herrnstein's equation and is represented as:

$$R = \frac{kr}{r + r_0} \qquad \text{(Equation 2)}$$

where R is the target response, k, a constant, is the maximum rate of responding that can occur within a given unit of time, r is the known rate of reinforcement for the target response and r_o is the rate of reinforcement for all other behaviors occurring (de Villiers & Herrnstein, 1976; Herrnstein, 1970; Herrnstein, 1974). According to this equation, the target response will vary with the amount of extraneous reinforcement (r_o) competing against the target response.

Student behavior has been described in terms of this equation. Martens and Houk (1989) fit Herrnstein's equation to the behavior of a 16-year-old with mental retardation. The researchers measured the time spent engaged in classroom behaviors (e.g., on-task and off-task) and the respective rates of naturally occurring reinforcement in the classroom environment (e.g., teacher attention). Martens and Houk were able to account for 83% of the variance in disruptive behavior and 44% of the variance in on-task behavior. In a similar study with a six-year-old student, Martens, Halperin, Rummel, and

Kilpatrick (1990) were able to account for 51% of the variance in on-task and 47% of the variance in off-task behavior through the use of the strict matching formula.

Martens, Lochner, and Kelly (1992) showed how these findings could be applied. Teachers were prompted to deliver social reinforcement based on different reinforcement schedules. While choice of behaviors was different (i.e., engaging in assignments vs. all other behaviors as opposed to choosing between two academic tasks), results were similar to those found by Mace et al. (1990). Students matched rates of responding to relative rates of reinforcement.

Relative rates of reinforcement will not always account for choice behavior (Baum, 1974; Wearden & Burgess, 1982). Variations in reinforcement delay, amount and quality can also affect choice behavior (e.g. Heyman & Monaghan, 1994; Petry & Heyman, 1994; Rachlin & Green, 1972). Additionally, response effort has also been shown to affect subjects' response preferences (e.g. Aparicio, 2001; Sumter, Foster, & Temple, 1995).

Neef et al. (1992) investigated interactions of reinforcement rate and quality by using high quality reinforcers (i.e., nickels) versus low quality reinforcers (i.e., program money). Neef et al., (1993) demonstrated subjects' differential responding to variations in reinforcement rate, quality, and delay (i.e., delivery of reinforcement at the end of experimental session versus some later date). Neef et al. (1994) investigated changes in responding due to the above reinforcement parameters as well as the effects of response effort (i.e., ease of which problems could be completed). Additionally, these studies show patterns of responding much like that of the basic operant research. Students' choice behavior was systematically affected by changes in reinforcement rate, quality, delay and response effort. These studies demonstrate the effects of reinforcement on academic responding. However, the designs and settings in which they occur were "education-like". While the tasks were of an educational nature, the setting was artificial (e.g., students seated at a table with an experimenter dropping nickels in cups). A better demonstration of matching would be description of student behavior as it occurs in an academic setting (e.g. Martens et al., 1990; Martens & Houk, 1989).

Shriver and Kramer (1997) used the matching law to account for naturally occurring student behavior in the classroom relative to teacher behavior. Shriver & Kramer recorded student behaviors in grade school classrooms during reading time. Classrooms were split into two groups. In some rooms, the instructor worked with one group at a time while the other group (without teacher attention) worked either independently on reading assignments or on some type of group reading project. In others, reading time consisted of taking turns reading passages aloud and then working individually or in pairs on spelling and comprehension problems. The matching law was able to account for large amounts of the variance in the students' reading behaviors. The students' rates of academic responding were systematically affected by both the types of tasks and attention (e.g., peer vs. teacher attention).

Strict matching and Herrnstein's Equation are based on situations where it is assumed that reinforcement quality is equivalent for competing behaviors. In natural environments such as classrooms, this is not the case. Reinforcement can vary for any particular behavior in amount and quality. Also, any single behavior could be reinforced with a variety of stimuli within a given time period. For example, engaging in seatwork could be reinforced by teacher attention, access to some other activity, or tangible reinforcement while off-task behavior might be reinforced by attention from multiple peers. In these cases, it would be difficult to equate or quantify reinforcement quality for each behavior. Immediacy of reinforcement can also vary. For example, disruptive behaviors may be immediately reinforced through peer attention or escape from educational activities while reinforcement for target classroom activities may be delayed.

The effort required for any two competing behaviors in classroom settings can also vary. Academic responding may require a greater amount of effort than other behaviors. To obtain reinforcement for an academic behavior, a student may have to complete a difficult series of tasks. However, to obtain reinforcement for a non-academic behavior, a student may only be required to throw a pencil. In such instances, it is difficult to measure or equate response effort for competing behaviors and neither the strict matching equation nor Herrnstein's equation would accurately account for choice behavior. Researchers have developed a formula to account for differences in both reinforcement and response parameters. This equation, known as the generalized matching equation is mathematically represented as:

$$\log\left(\frac{R1}{R2}\right) = a\log\left(\frac{r1}{r2}\right) + \log c \quad \text{(Equation 3)}$$

The a component would account for differences in reinforcer type (e.g., teacher attention vs. peer attention) and the c component accounts for differences in response form and effort (e.g., seatwork vs. jokes).

As discussed by Billington and DiTommaso (2003), the generalized matching equation has not been widely applied in the educational setting (i.e., data not fit to the equation). While wide application has not occurred, the reinforcement and response parameters that the generalized matching equation assesses have been investigated. Researchers have conducted a series of studies investigating the effects of relative reinforcement rates, quality (nickels versus tokens), delay (delivery of reinforcement at the end of experimental session versus some later date), and response effort on student choice behavior (c.f., Mace et al., 1990; Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994). Although variables like reinforcement quality and relative response effort often vary across students (e.g., teacher attention is a higher quality reinforcer for some students than others, mathematics assignments are less effortful for some students), studies investigating these variables have important educational implications. For example, Neef et al., (1994) found that four of the six subjects preferred completing higher effort tasks (difficult mathematics problems) when they were associated with higher rates of reinforcement. Other students preferred high quality reinforcers delivered at low rates to lower quality but higher rate reinforcement. Finally, some students preferred immediacy of reinforcement over all other conditions.

Billington and DiTommaso (2003) provide many examples of variables other than rates of reinforcement influencing student choice behavior. The cited studies indicate how different variables interact and affect choice behavior differently across subjects. Furthermore, these studies provide examples of how basic theory can be applied in educational settings where many different causal variables interact and influence choice behavior in accordance with the matching law.

These psychoeducational studies provide valuable information about concurrent reinforcement and choice. When given choices, students should choose behaviors offering higher rates of reinforcement, higher quality reinforcers, more immediate reinforcement, and less effortful responding. The matching law has been used to predict and control students' behaviors in academic settings. Researchers have found that as the rates of reinforcement between academically desirable and undesirable behaviors widens, so do the frequencies of those behaviors (Martens & Houk, 1989; Martens et al., 1992). However, teachers may find it difficult and time consuming monitoring each student's behavior and delivering reinforcers contingent upon desirable behavior within the classroom environment.

Methods of Assignment Alteration

There are many procedures that can influence assignment choice as well as perceptions of assignments. Dunlap et al. (1994) found students could be influenced to engage in seatwork more often by merely giving choices among assignments. Besides allowing students to make choices among assignments, altering the assignment content can influence choice among students (Dunlap & Kern 1996).

Altering assignments by shortening assignment length or replacing new unlearned material with previously learned material decreases the time and effort required by students to complete assignments and will influence students' choice in favor of those altered assignments (e.g. Cooke et al., 1993; Winterling et al., 1987). While students may be more likely to engage in those assignments requiring less time and effort, learning may be adversely affected when such assignments are chosen (Binder, 1996; Logan & Skinner, 1998, Roberts et al., 1996; Roberts & Shapiro, 1991). If educators can develop assignments that students prefer and increase opportunities to respond, academic achievement may be enhanced and inappropriate behaviors decreased (Cates & Skinner, 2000; McCurdy et al., 2001; Skinner et al., 1996).

While the matching law can be applied to reduce inappropriate behaviors, classroom environments must also enhance academic skill development. Educators should design materials that will assist students in developing speed and accuracy in the performance of those basic academic skills (i.e., reading, arithmetic, etc.). Once these skills have been developed, increasing the opportunities to respond or the time engaged in assignments can further develop fluency in those skills as well as students' ability to generalize mastered skills to new tasks (Greenwood et al., 1984; Skinner, Fletcher, & Henderson, 1996).

Rate of reinforcement, reinforcer quality, immediacy, and response effort have all been shown to influence choice in a systematic fashion. Researchers using principles of the matching law have had success in influencing students' choice behavior as well as improving perceptions of those assignments. Some researchers have developed a theory (discrete task completion hypothesis) that states that, in one's past, completing some type of task (e.g., mathematics problems, grammar assignments) has become a reinforcing event. If this is true, then assignments that contain more reinforcers (i.e., completed discrete tasks)-per-unit-of-time (i.e., richer schedule of reinforcement) will be chosen over those with fewer reinforcers (Skinner, 2002).

The Discrete Task Completion Hypothesis and Interspersal Procedure

A theoretical model for how academic behaviors are reinforced within assignments has been developing. Skinner (2002) theorized that through the process of classical conditioning, completion of a discrete problem becomes a reinforcing event. Skinner (2002) reasoned that since in a student's history an activity has often been followed by reinforcement (i.e., praise, tangible reinforcers, access to some other preferred activity), the continued pairing of completed assignments with the established reinforcers transforms completion of an assignment into a reinforcing event. Since the last event to occur before completion of an entire assignment is the completion of a discrete task, completion of these discrete tasks become reinforcing events through the process of higher order conditioning. If completion of a discrete task is a reinforcing event then, as the matching law predicts, increasing the problems completed per-unit-of-time within an assignment will influence choice for that assignment relative to another.

A variety of studies have supported this theory. Skinner et al. (1996) presented students with two mathematics worksheets. The control sheet contained 16 three-digit-by-two digit (3x2) multiplication problems (target problems). The experimental sheet contained 16 similar target problems with six additional one-digit-by-one-digit (1x1) multiplication problems interspersed after every third target problem. Students were instructed to work on each assignment for equal amounts of time. After exposure to both assignments, students indicated which was more difficult, more time consuming and which assignment would require more effort to complete from start to finish. Finally, students were told that they were going to be given a homework assignment similar in design to one of the two they had just worked, but that they could choose which type of assignment (i.e., experimental or control) they would complete. Analysis of the performance data revealed that accuracy and the number of target problems competed were not significantly different. Significantly more students chose the experimental assignment for homework and problem completion rates were significantly higher on the experimental assignment. The researchers also found that significantly more students chose the control assignment as being more difficult, more time consuming, and effortful than the experimental assignment. Skinner et al. (1996) posited that if completing a problem is a reinforcing event, this difference in problems completed per unit-of-time could account for the choice of the experimental assignment. Hence, the brief 1x1 problems (interspersal problems) increased the reinforcement rate and as the matching law predicts, more responding will be allocated to the higher rate of reinforcement. As opposed to other methods of altering academic assignments (e.g. Cooke et al., 1993; Winterling et al., 1987), it is worth noting that interspersing the brief problems did not reduce opportunities to respond to the target tasks (3x2 digit multiplication problems).

Skinner, Hall-Johnson, Skinner, Cates, Weber, and Johns (1999) further investigated the idea of problem completion as a reinforcing event. The researchers presented a series of four pairs of multiplication assignments to students. The first pair consisted of a control assignment containing 18 four-digit-by-one-digit multiplication problems (4x1) and an experimental assignment containing 18 similar 4x1 problems with six 1x1 problems interspersed after every third 4x1 problem. The second assignment pair contained 18 four-digit-by-two-digit (4x2) problems with an experimental assignment containing 18 4x2 problems with six 1x1 problems interspersed after every third 4x2 problem. The third assignment pair consisted of a control with 18 four-digit-by-three-digit multiplication problems (4x3) and an experimental assignment with 18 similar 4x3 problems with 1x1 problems interspersed after every third 4x3 problem. Finally, a fourth assignment pair was presented containing 18 four-digit-by-four-digit (4x4) multiplication problems with an experimental sheet made up of 18 similar 4x4 problems with six 1x1 multiplication problems interspersed after every third 4x4 problem. After completion of each assignment pair students were asked choose which of the two assignments within each pair would be more time consuming, difficult, and effortful to complete. Students were then asked to choose a homework assignment similar to one they had just worked for each assignment pair.

Analysis of the target problem performance data revealed no significant differences within each assignment pair. Thus, interspersing the brief problems did not reduce opportunities to respond. Analysis of the choice data and its relation to the total number of problems completed across assignment pairs supported the discrete task completion hypothesis and demonstrates a matching relationship. For each assignment pair, the researchers computed a *Relative Problem Completion Rate* (RPCR). The RPCR is a ratio obtained by dividing the total number of problems on the experimental assignment (target problems plus interspersal problems) by the total number of problems completed on the control assignment. In all assignment pairs, the total number of problems completed on the experimental assignment was significantly greater than the number of problems completed on the control that yields a ratio greater than one. The researchers demonstrated that as the complexity increased across assignment pairs (i.e. 4x1 problems vs. 4x4 problems) the total number of problems completed decreased, while the RPCR for each assignment pair increased. Results showed that as the RPCR increased for each assignment pair, so did the proportion of students choosing the experimental assignment. For example, the 4x1 assignment pair yielded a RPCR of 1.335 vs. the 4x3 assignment pair with a RPCR of 1.562. The percentage of students choosing the experimental assignments for homework was 70% and 84% respectively.

These results resemble findings in choice studies with single subjects using more typical reinforcers including tokens, money, and attention (Mace et al., 1990; Martens et al., 1992; Neef et al., 1992). As a higher rate of reinforcement influenced choice behavior in these studies, a higher rate of problems completed per-unit-of-time influenced choice behavior in the interspersal studies. In a meta-analysis, Skinner (2002) examined eight interspersal studies and found a strong relationship between problem completion rate and assignment choice. Skinner (2002) fit the results from these studies to a linear regression with RPCR predicting choice and obtained an r=0.82 and an r^2=0.66. Such analyses demonstrate a strong relationship between discrete task completion rates and assignment choice.

While most of the interspersal studies have involved students' choice of mathematics assignments, Teeple (2002) applied this procedure of interspersing brief problems to the grammar assignments of grade school students with behavioral disorders.

Students were presented with a control assignment containing 15 multi-sentence paragraphs (target paragraphs) and an experimental assignment containing 15 similar paragraphs with eight one-sentence paragraphs (interspersal paragraphs) interspersed after every two target-paragraphs. For each paragraph, students were required to copy each sentence within the paragraph inserting the proper punctuation. Students were required to work on each assignment for equivalent amounts of time and then required to answer questions about time, difficulty, and effort pertaining to the assignments and to choose a similar assignment for homework. Significantly more students (75%) chose the experimental assignment for homework. As in previous studies with mathematics assignments, the total amount of items (in this case, paragraphs) completed on the experimental assignments (targets plus interspersals) exceeded the number of items completed on the control, but total number of target paragraphs completed on each assignment was not significantly different.

Using the interspersal procedure can influence student assignment choice as well as enhance perceptions of those assignments. The discrete task completion hypothesis states that a completed discrete task within academic assignments is a reinforcing event (Skinner, 2002). Researchers using the interspersal procedure have demonstrated interspersing brief problems among target tasks enhances relative problem completion rates and influences student choice (Logan & Skinner, 1998; Skinner et al., 1996). These results resemble research findings from educational research using typical reinforcers (e.g., money, food, etc.). Also, as opposed to other methods of assignment alteration, interspersing brief tasks does not reduce opportunities to respond to target academic tasks (Skinner, Hall-Johnson et al., 1999).

Assignment Effort

A facet of this research that has not been dealt with in great detail pertains to the amount of work completed on the experimental assignment relative to the control assignment. In most interspersal studies on choice behavior, the total amount of work completed on the experimental assignments *exceeded* the amount of work completed on the control assignments, while students perceived the chosen homework assignments as requiring less time, effort, and as being less difficult (Skinner, Hall-Johnson et al., 1999; Wildmon et al., 1998). While the additional problems may have not added any real instructional value (e.g. 1x1 multiplication problems), the notion of influencing students to do more work is intriguing.

Cates, Skinner, Watkins, Rhymer, McNeill, and McCurdy (1999) presented students with a control assignment containing 15 3x2 target multiplication problems and an experimental assignment containing 18 3x2 multiplication problems with six 1x1 multiplication problems interspersed after every third target problem. After working on both assignments for equal amounts of time, students were asked to choose a homework assignment. Also, students were asked to indicate which of the two assignments was more difficult, more effortful and which would require more effort to complete. Results showed that significantly more students chose the experimental assignment for homework as well as rating it more favorably. The researchers also presented the students with another assignment pair containing a worksheet with 15 3x2 problems and another with 18 (20% more) 3x2 problems. For this assignment pair, there was no significant difference in assignment preference or homework choice. The researchers concluded that interspersing brief problems could influence students to choose assignments requiring more effort (quantitatively more problems).

Cates and Skinner (2000) further explored the idea of getting students to choose assignments containing more target problems. Remedial mathematics students were presented three different assignment pairs each containing a control assignment with 15 3x2 multiplication problems and experimental assignments containing either 15 (0% more), 18 (20% more), and 21 (40% more) 3x2 problems with 1x1 multiplication problems interspersed after every third target problem. In every assignment pair, students rated the experimental assignment more favorably on time, effort and difficulty and chose the experimental assignments for homework.

Cates and Skinner (2000) and Cates et al. (1999) demonstrated that using the interspersal procedure could influence students to choose assignments containing more difficult, higher effort problems (e.g., more target problems). However, in these studies students were not actually required to complete either the control or experimental assignments. Billington and Skinner (2002) replicated and extended the findings of Cates and Skinner (2000). College students were presented with two assignment pairs. Both assignment pairs contained a control consisting of 15 3x2 multiplication problems (target problems) and an experimental assignment containing 18 similar target problems with 1x1 multiplication problems interspersed after every third target problem. On the first assignment pair students were required to work each assignment for an equal amount of time (i.e., five minutes each). After completing this assignment pair, students were asked to answer questions about time, difficulty and effort as well as make a homework choice. On the second assignment pair, students were told to work each assignment to completion, answer questions about time, difficulty and effort and finally to make a homework choice. Results from the first assignment pair replicated that of Cates and Skinner (2000). However, when students were required to complete both assignments, choice was not significant for either assignment. Students did not choose the assignment requiring fewer target problems as would be expected. The researchers suggested that using the interspersal technique might influence students to engage in assignments requiring more target problems. Thus, the interspersal procedure may be a valid way of increasing opportunities to respond.

Meadows (2001) required grade school students to work on two language arts assignments for 10 minutes each. Experimental assignments contained 24 language arts tasks with eight brief tasks interspersed within the assignment. Control assignments contained 20 equivalent language arts tasks. In this study, target tasks included identification of predicate nouns and adjectives; transitive and intransitive verbs; and direct and indirect objects. The brief tasks consisted of two word sentences where students were required to circle the verb. Meadows found that significantly more students chose the experimental assignment containing more total problems. However, students were not required to complete either assignment.

In her second experiment, Meadows (2001) required students to complete an additional assignment pair. The experimental assignment contained six target items with two brief items (one interspersed after every third target item). The control assignment contained five target items. Results showed that when students were required to choose an assignment for homework, significantly more students chose the experimental assignment for homework.

Summary and Purpose

Influencing student choice is important. If educators can develop procedures that cause students to choose to engage in academic tasks, learning rates can be enhanced and disruptive behaviors decreased. Basic and applied researchers have identified variables that affect student choice. Reinforcement rate, quality, immediacy, and response effort have been shown to affect academic responding. However, monitoring and delivering reinforcement may prove difficult and time consuming within classrooms. Recently, researchers have developed a theory (discrete task completion hypothesis) and procedure (interspersal procedure) that can affect student assignment choice. These researchers have found that by interspersing brief problems, students will not only choose assignments containing equivalent target tasks relative to a control but will choose assignments containing more target tasks.

Research on student choice behavior suggests that when given the choice of two assignments, students will choose to engage in assignments that require less time and effort to complete (Cooke et al., 1993; Dunlap & Kern, 1996). Research on the interspersal procedure suggests that one way to influence students to choose assignments requiring more effort is to enhance problem completion rates by interspersing additional brief discrete tasks (Cates & Skinner, 2000; Cates et al., 1999; Logan & Skinner, 1998;

Skinner et al., 1996; Wildmon, Skinner, McCurdy, & Sims, 1999). The current study sought to extend research on the relationship between relative problem completion rates and task effort by exposing students to two pairs of assignments. Rather than increasing the number of problems in assignments, assignment effort was altered by modifying the number of steps required to complete problems. In Assignment Pair A, students worked on high effort and moderate effort assignments. In Assignment Pair B, high effort assignments were modified by interspersing additional brief problems to determine if the interspersal procedure would increase relative task complete rates and enhance students' perceptions of the high effort assignment and the probability that students would choose the high effort assignment for homework.

CHAPTER III

EXPERIMENT I

Methods

Participants and Setting.

All 51 students (34 females and 17 males) from an undergraduate psychology course participated in this study. Mean age of the students was 26.14 years. The setting for this experiment was the students' psychology classroom.

Materials.

During the experimental session, students were required to work mathematics computation problems from two pairs (Assignment Pair A and Assignment Pair B) of mathematics assignments (total of four assignments). Each assignment was presented on one side of an 8.5x11-in. sheet of white paper. Each assignment contained a title and a series of mathematics problems. Each assignment pair contained a high-effort assignment and a moderate-effort assignment.

Assignment Pair A. For Assignment Pair A, the high-effort assignment contained 18 long three-digit by two-digit (3x2) computation problems. To ensure that students had to carry for each calculation, all digits within the problems were greater than three. The moderate-effort assignment also contained eighteen 3x2 multiplication problems. Nine problems were long problems and every other problem was a moderate problem. Moderate 3x2 problems were composed of numerals less than four with the exception of the hundreds place. This ensured that students did not have to carry. An example of a long problem would be 56 x 498 = ____. An example of a moderate problem would be 32 x 811 = _____.[1]

Assignment Pair B. Assignment Pair B contained a moderate-effort assignment similar in design to that used in Assignment Pair A. The high-effort interspersal assignment was similar to the high-effort assignment used in Assignment Pair A, however six additional one-digit by one-digit (1x1) brief problems were interspersed after every third 3x2 problem. Thus, this assignment contained 24 problems (18 long problems and 6 brief problems).

Within each assignment pair, efforts were made to equate long problems across assignments. Specifically, each long problem on the moderate-effort assignment was matched to the corresponding problem on the high-effort assignment by altering digit sequences. For example, in Assignment Pair A if the third problem on the high effort assignment was 76 x 469 = _____, the third problem on the moderate-effort assignment (a designated Long Problem) could have been 67 x 649 = _____. Altering the sequence of digits within factors has been found to be an effective strategy for creating equivalent problems across assignments (see Skinner, Robinson et al., 1996- Experiment III).

Problems on each assignment were presented in four rows. Problems were not numbered, spaced evenly or consistently, or presented with equal numbers of problems across rows or columns. This unbalanced presentation format was used to reduce the probability of students performing a quantitative analysis of the number of target and/or interspersed problems. For each student, assignments were titled one of the following:

---

[1] Experimental materials are presented in Appendix C.

Assignment E, Assignment Z, Assignment I, and Assignment B. Assignment titles were counterbalanced across assignments.

Experimental packets. Assignments were combined with sheets that were used to collect informed consent, provide instructions, collect demographic data, and data on students' perceptions and homework choice. Thus, each student was given a packet containing eight sheets of paper (See Appendix C for an example). The cover sheet contained a description of the research and statement of informed consent. The second page contained the directions for the assignments. The next two pages were composed of Assignment Pair A or B. The next page was a sheet to record demographic data and answer questions about the assignment pair they had just worked on. Specifically, after working on each pair of assignments, students recorded which of the two assignments (Assignment E, Z, I, or B) was more difficult, would require more time to complete, and would require more effort to complete. After recording their perceptions, the experimenter read a brief statement which stated that in order to receive full extra credit, they would have to complete an additional assignment for homework, but they could chose which type of new assignment they would complete. This constituted the first assignment set of the experiment. The next two pages contained the second assignment pair, followed by a page where students recorded their perception and choice data.

Each assignment pair was presented in counterbalanced order across students (i.e., half completed Assignment Pair A first and half completed Assignment Pair B first). Within pairs, assignments were also presented in counterbalanced order, so that half received the high-effort assignment first and half received the moderate-effort assignment first.

Procedures.

Students were first instructed to read and sign the informed consent statement (See Appendix C). An experimenter then instructed the students to follow along as the directions were read. These directions informed the students that they were going to work mathematics problems. Students were instructed to work problems from left to right without skipping any problems and to work as quickly as possible without sacrificing accuracy. The experimenter started a stopwatch and instructed the participants to begin working on the first assignment. After four minutes, students were told to cease work on the first assignment. The experimenter re-set the stopwatch and instructed students to turn the page and begin working on the second assignment. At the end of the second four-minute interval, students were told to stop working and turn to the next page.

Students recorded demographic information and responded to questions pertaining to the assignments they had just worked. Students were asked to consider the two previous assignments they had worked and record: 1) Which worksheet was more difficult? 2) Which worksheet would require more effort to complete from start to finish? 3) Which worksheet would require more time to complete from start to finish? Before recording their perceptions data, students were told that they could look back over their assignments. Finally, students were told that they would have to complete one more sheet from beginning to end for homework. However, they may choose which type of worksheet they would like to complete by circling their choice on the questionnaire.

Students were told that the problems would not be identical to those they had just worked, but for each assignment, the type and number of problems would be identical. After recording their choice data from the first assignment pair, identical procedures were run with the second assignment pair.

Dependent Variables and Data Analysis Procedures.

The dependent variables in the current study included assignment perceptions (i.e., time, effort, and difficulty) and homework choice data. Furthermore, mathematics performance data was analyzed. This analysis included a) number of 3x2 problems completed, b) percent problems correct and c) total number of problems completed (3x2 plus interspersal problems in Assignment Pair B).

Analyses were conducted to test for differences within each assignment pair and across assignments (i.e., interactions). Chi square tests were used to analyze data on perceptions and choice and dependent t-tests and ANOVAs were used to test for differences in mathematics performance. For each analysis, differences were considered significant at the $p<0.05$ level.

Interscorer Agreement.

Using an answer sheet, one experimenter recorded the number of problems correct and the number of problems completed for each assignment sheet. A second scorer independently recorded the same data on 50% of the assignments. Interscorer agreement was 100% for problem accuracy and problems completed.

Results

Mathematics performance data is summarized in Table 1. Homework choice and assignment perception data is summarized in Table 2.[2]

Within Assignment Analyses.

Analysis of Assignment Pair A (High Effort vs. Moderate Effort). Table 1 shows that for Assignment Pair A, the total number of problems completed for the high-effort and moderate-effort Assignments was M=7.37 (SD=2.23) and M=10.47 (SD=2.93) respectively. Dependent t-tests show that this difference is statistically significant ($t = 10.49$; $df = 50$; $p < 0.0001$). Mean accuracy for the two assignments was also significantly different ($t = 2.80$; $df = 50$; $p < 0.0073$). The mean accuracy for the high-effort assignment was 65.99% (SD=27.53) and 77.41 (SD=16.59) for the moderate-effort assignment.

Table 2 provides a summary of perception and choice data. For Assignment Pair A, chi-square analysis showed that significantly more students (38 of 51 participants) chose the moderate-effort assignment for homework ($\chi^2 = 12.25$; $df = 1$; $p < 0.005$). Analysis of the perception data shows that for Assignment Pair A significantly more students selected the high-effort assignment as being more difficult ($\chi^2 = 10.37$; $df = 1$; $p < 0.001$), and indicated that it would require more effort ($\chi^2 = 12.25$; $df = 1$; $p < 0.005$) and time to complete ($\chi^2 = 14.29$; $df = 1$; $p < 0.0002$).

The two assignments comprising Assignment Pair A were purposelyconstructed so that the high-effort assignment required more time and effort to complete and be more

---

[2] All tables presented in Appendix A.

difficult. Both mathematics performance data and student perception data suggest that the experimenters achieved their goal.

Analysis of Assignment Pair B (High Effort Interspersal vs. Moderate Effort). Table 1 shows for Assignment Pair B, that the mean number of total problems (1x1 plus 3x2) completed for the high-effort interspersal assignment (*M*=11.65; *SD*=2.90) was greater than the moderate-effort assignment (*M*=10.02; *SD*=2.63). This difference was statistically significant ($t = -5.90$; $df = 50$; $p < 0.0001$). Table 1 summarizes accuracy data for 3x2 problems across the two assignments in Assignment Pair B. The mean accuracy for the high-effort assignment was 73.66% (*SD*=19.15) and 78.47 (*SD*= 18.29) for the moderate-effort assignment. This difference was not significant ($t=1.65$; $df=50$; $p=.11$). The mean number of 3x2 problems completed was 10.02 (*SD*=2.63) for the moderate effort assignment and *M*=8.35 (*SD*=2.90) for the high-effort interspersal assignment. Analysis showed a significant difference between the number of 3x2 problems completed on the moderate-effort assignment and high-effort interspersal assignment ($t = 6.32$; $df = 50$; $p < 0.0001$).

Table 2 provides a summary of choice and perception data for Assignment Pair B. Although 30 of 51 students chose the high-effort interspersal assignment for homework, chi-square analysis showed no significant differences for homework choice ($\chi^2 = 1.59$; $df = 1$; $p = 0.21$). Significantly more students ranked the high-effort interspersal assignment as being less difficult ($\chi^2 = 6.48$; $df = 1$; $p = 0.011$). No significant differences were found for time ($\chi^2 = 0.02$; $df = 1$; $p = 0.89$) or effort ($\chi^2 = 3.14$; $df = 1$; $p = 0.07$) rankings.

Across Assignment Pair Analyses.

Mathematics Performance. Assignment Pair B was constructed to determine if interspersing additional brief problems on the high-effort assignment would a) increase problem completion rates on the high effort assignment b) increase the proportion of students choosing the high effort assignment for homework, and c) enhance students' perceptions of the high effort assignments.

Interspersing the brief problems caused an increase in the number of problems completed on the high-effort assignment (7.37 on the high effort to 11.65 on the high effort with interspersed brief problems). ANOVA showed a significant difference among the total number of problems completed across assignments ($F= 20.97$, $df=4$, $p<0.0001$). Results from Tukey's Post Hoc Analysis (presented in Table 4 with effect sizes for significant differences) revealed a significant difference between the total number of problems completed on the High Effort Assignment in Assignment Pair A and the High Effort Interspersal Assignment (long problems plus brief problems) in Assignment Pair B. No significant differences were found between the Moderate Effort Assignments.

One concern with interspersing additional brief problems is this procedure may reduce opportunities to respond to longer target items. Results showed that interspersing the brief problems did not decrease the number of long target problems completed on the high-effort assignment (mean of 7.37 on the high effort increase to mean of 8.35 on the high effort with interspersed brief problems). Tukey's Post Hoc Analysis showed no significance difference between the 3x2 problems completed on these assignments.

Differences in accuracy were found in Assignment Pair A (i.e., students were more accurate on the Moderate Effort Assignment than the High Effort Assignment), but not in Assignment Pair B. An ANOVA was performed to test for differences in accuracy across assignment pairs. Results from the ANOVA revealed significant differences across Assignment Pairs (*F=3.75, df=3. p=0.012).* Tukey's Post Hoc Analysis (Table 4) showed accuracy between the Moderate Effort and High Effort Assignments was insignificant. However, accuracy on the High Effort Assignment in Assignment Pair A was significantly lower than the accuracy for both Moderate Effort Assignments.

Choice and Perception Analysis. Pearson's Chi Square Analysis (displayed in Table 3) shows a significant shift in choice. Significantly more students chose the high-effort assignment for homework in Assignment Pair B (30 or 58%) relative to Assignment Pair A (13 or 25.49%). Additionally, significantly fewer students ranked the high-effort assignment as being more difficult and requiring more time and effort to complete for Assignment Pair B, relative to Assignment Pair A. The results show that interspersing the brief problems caused significantly more students to choose the high-effort assignment for homework and rate the high-effort assignment more favorably for time, effort, and difficulty.

Shifts in choice and perceptions were analyzed by creating 2x2 contingency tables for each of the choice and perception categories and assessing the effect of adding the interspersal problems. Pearson Chi-Square (Q_p) and odds ratios are presented in Table 3. For each category, there is a strong association between the addition of the interspersal problems and selection (every Q_p significant at the $p<0.01$ level). Analysis of the odds ratios reveals students were approximately four times (OR=3.99) more likely to choose the high effort assignment for homework when the interspersal problems are added. Also, students were more likely to perceive the high effort assignments as being less difficult (OR=5.2), time consuming (OR=4.67) and effortful (OR=3.04). These data suggest that the interspersing of brief problems influences students to choose the assignments consisting of all high-effort problems.

Regression Model

To assess the predictive nature of relative problem completion rates and student assignment choice, a logistic regression model was employed. The model supplies the probability of choosing the high effort assignment for obtained RPCRs.

Logistic regression analysis shows a significant main effect for RPCR ($Q_W=13.3743; df=1; p=0.0003$). The Hosmer and Lemeshow Goodness of Fit test shows the model fits adequately ($Q_{WS}=11.6443; df=7; p=0.1129$). Relative problem completion rates are plotted against the predicted probabilities from the model in Figure 1.[3]

Discussion

In the current study, students were exposed to two assignment pairs. While working on the first assignment pair, students completed significantly more 3x2 multiplication problems on the moderate-effort assignment than on the high-effort assignment and accuracy levels where higher on the moderate effort assignment. These results suggest that the researchers' were successful in their attempt to create assignments requiring unequal amounts of effort while maintaining equal numbers of problems on

[3] Figures are displayed in Appendix B.

both assignments. On Assignment Pair A, significantly more students rated the moderate effort assignment as requiring less time and effort to complete and as being less difficult than the high effort assignment. Thus, student assignment perception data suggests that students were able to detect the differences across assignments.

Analysis of Assignment Pair A showed significantly more students chose the moderate effort for homework. This finding supports previous research that suggests that when given a choice of two assignments and all other variables are held constant, students will choose the assignment that requires less effort to complete (Cooke et al., 1993; Winterling et al., 1987). However, if a completed discrete task is a reinforcing event, in Assignment Pair A students may have chosen the moderate effort assignment because it was associated with higher discrete problem completion rates and rates of reinforcement (Skinner, 2002).

In Assignment Pair B, additional interspersed brief problems were added to the interspersal assignment. This procedure increased the effort required to complete the high effort assignment and increased discrete task completion rates on the high effort assignment. The increase in effort should cause a decrease in the probability of student choosing the high effort assignment. However, if the discrete task completion hypothesis is accurate, increasing problem completion rates would have the opposite effect and increase the probability of students choosing the high effort assignment. Results from Assignment Pair B showed significant increases in the proportion of students choosing the high effort assignment. Additionally, ratings of time, effort, and difficulty improved significantly when additional brief problems were added to the high effort assignment.

Thus, the current results support previous research on the discrete task completion hypothesis which suggests that adding and interspersing brief problems can improve students' perceptions of high effort assignments and increase the probability of students choosing to engage in higher effort assignments.

Theoretical Implications, Limitations, and Future Research.

In Assignment Pair A, students may have chosen the moderate effort assignment because it required less time and effort to complete than the high effort assignment. However, in Assignment Pair B the only modification was to intersperse *additional* problems to the high effort assignment. While these additional problems may not have caused a large increase in the effort required to complete the high effort assignment, they could not have decreased the effort required to complete the high effort assignment. Thus, relative effort cannot explain the increase in the proportion of students choosing the high effort assignment in Assignment Pair B. Thus, the current study extends research on the discrete task completion hypothesis by controlling for effort.

The current study provides additional support for the hypothesis that when given an assignment composed of multiple discrete tasks, the completion of each discrete task may be a reinforcing event. However, this support is indirect. Before researchers conclude that a completed discrete task is a reinforcing event, they should conduct studies designed to more directly address this hypothesis and investigate the process whereby these events become reinforcers. For example, researchers should determine if providing high rates of immediate high quality reinforcement for assignment completion cause discrete complete tasks to become stronger conditioned reinforcers.

Reducing the effort required to complete assigned work can enhance students' perceptions of assignment, increase the probability of students choosing to engage in assigned work, and decrease the probability of students engaging in disruptive behaviors (Cooke et al., 1993; Dunlap & Kern, 1996; Winterling et al., 1987). However, reducing assignment demands can also reduce learning (Roberts & Shapiro, 1996; Roberts et al., 1991). The current study suggests that student perceptions of assignments can be enhanced and the probability of them choosing to engage in higher effort tasks also can be enhanced by interspersing additional brief tasks. This suggests that educators may be able to enhance assignment perceptions and decrease off-task behavior without reducing assignment demands.

While the interspersal procedure appears to have strong applied value, future research is needed to address several limitations associated with the current study. Participants in the experiment were undergraduate volunteers participating for extra credit. The 3x2 digit target multiplication problems were not part of their curricula and consequences were not delivered contingent upon mathematics performance. Thus, these results may not generalize to course relevant and grade contingent assignments. In order to enhance the external and educational validity of the current study, researchers should conduct similar studies with students utilizing educationally relevant tasks (e.g., grade school students who have just learned the steps needed to complete 3x2 problems with carrying).

CHAPTER IV

EXPERIMENT II

Methods

Experiment two addresses the issue of ecological and educational validity by utilizing students (sixth grade elementary school students) where the target tasks are appropriate for their skill level.

Participants and Setting.

The participants in this study included 44 students from six mathematics classes enrolled at a local public school in the southeastern U.S. Participation in the study was voluntary. Students in one mathematics class were not able to perform the tasks (teacher recommendation) and were excluded from the study. Informed written consent of the parent/guardian and student written assent were required from each participant prior to implementation of the experiment (see Appendix C). All students who returned parental/guardian written consent provided written assent. Participants were informed that they could cease participation in the study at any time without penalty or loss of services to which they were entitled. No students withdrew during the course of this project. Any student who failed to follow instructions was excluded from the study (e.g., skipping items, failure to respond to post-assignment questions).

The experiment was conducted during the participants' regularly scheduled mathematics class with the teacher and other students present. The students sat in their assigned seats with no materials, other than a writing utensil. Students were not allowed to use class materials (e.g., notes, text, calculator, etc.) to assist them with the assigned tasks involved in the experiment, nor were the students allowed to talk to classmates during the activity. The experimental procedure took approximately 15 minutes of the allotted 90-minute class period. A graduate student in experimental psychology served as the primary researcher for this project. The general education teacher of the classes selected for this study was present during the experimental procedures. A graduate student in elementary education assisted the primary researcher during the actual data collection.

Materials.

During the experimental sessions, students were required to work mathematics computation problems from two pairs (Assignment Pair A and Assignment Pair B) of mathematics assignments (total of four assignments). Each assignment was presented on one side of an 8.5x11-in. sheet of white paper. Each assignment contained a title and a series of mathematics problems. Each assignment pair contained a high-effort assignment and a moderate-effort assignment. Each assignment pair in Experiment Two was identical to those of Experiment One.

Experimental packets. Two assignment packets were used for this experiment. Assignments were combined with sheets that were used to provide instructions, collect demographic data, and data on students perceptions and homework choice. Thus, each student was given a packet containing four sheets of paper. The cover sheet contained a description of the research and the directions for the assignments. The next two pages were composed of Assignment Pair A or B. The next page was a sheet to record demographic data and answer questions about the assignment pair they had just worked on. Specifically, after working on each pair of assignments, students recorded which of the two assignments (Assignment E, Z, I, or B) was more difficult, would require more time to complete, and would require more effort to complete. After recording their perceptions, the experimenter read a brief statement that stated they would have to complete an additional assignment for homework, but they could choose which type of new assignment they would complete. This constituted the first assignment set of the experiment and was delivered on day one of Experiment Two. On day two of this experiment, the second assignment packet was presented. This assignment packet was identical in design to the first packet.

Each assignment pair was presented in counterbalanced order across students (i.e., half completed Assignment Pair A first and half completed Assignment Pair B first). Within pairs, assignments were also presented in counterbalanced order, so that half received the high-effort assignment first and half received the moderate-effort assignment first. Assignment titles were also counterbalanced within assignment pairs.

Procedures.

On day one, an experimenter instructed the students to follow along as the directions were read. These directions informed the students that they were going to work mathematics problems. Students were instructed to work problems from left to right without skipping any problems and to work as quickly as possible without sacrificing accuracy. The experimenter started a stopwatch and instructed the participants to begin working on the first assignment. After four minutes, students were told to cease work on the first assignment. Approximately 30 seconds after ceasing work on the first assignment, the experimenter reset the stopwatch and instructed the students to begin working on the second assignment.

Students recorded demographic information and responded to questions pertaining to the assignments they had just worked. Students were asked to consider the two previous assignments they had worked and record: 1) Which worksheet was more difficult? 2) Which worksheet would require more effort to complete from start to finish? 3) Which worksheet would require more time to complete from start to finish? Before recording their perceptions data, students were told that they could look back over their assignments. Finally, students were told that they would have to complete one more sheet from beginning to end for homework. However, they may designate which type of worksheet they would like to complete by circling their choice on the questionnaire. Students were told that the problems would not be identical to those they had just worked, but for each assignment, the type and number of problems would be identical. After recording their choice data from the first assignment pair, students were given their chosen assignment. This concluded day one of the experiment. On day two, homework assignments were collected at the beginning of the experimental session. Students were then instructed in a manner similar to day one. Homework assignments were distributed only on day one. This was done to ensure students carefully considered the perception and choice options.

Dependent Variables and Data Analysis Procedures.

Dependent variables and data analysis procedures were similar to those used in Experiment one.

Interscorer Agreement.

Using an answer sheet, one experimenter recorded the number of problems correct and the number of problems completed for each assignment sheet. A second scorer independently recorded the same data on 50% of the assignments. Interscorer agreement was 100% for problem accuracy and problems completed.

Results

Mathematics performance data is summarized in Table 6. Homework choice and assignment perception data is summarized in Table 7.

Within Assignment Analyses.

Analysis of Assignment Pair A (High Effort vs. Moderate Effort). Table 6 shows that for Assignment Pair A, the total number of problems completed for the high-effort and moderate-effort Assignments was M=3.77 (SD=1.75) and M=5.89 (SD=2.23) respectively. Dependent t-tests show that this difference is statistically significant ($t = 9.89; df = 43; p < 0.0001$). Mean accuracy for the two assignments was not significantly different ($t = 1.22; df = 43; p = 0.23$). The mean accuracy for the high-effort assignment was 73.21% (SD=21.03) and 66.01% (SD=25.25) for the moderate-effort assignment.

Table 7 provides a summary of perception and choice data. For Assignment Pair A, chi-square analysis showed that significantly more students (38 of 44 students) chose the moderate-effort assignment for homework *($\chi^2 = 23.27$; $df = 1$; $p < 0.0001$)*. Analysis of the perception data shows that for Assignment Pair A significantly more students (41of 44 students) selected the high-effort assignment as being more difficult *($\chi^2 = 32.82$; $df = 1$; $p < 0.0001$)*, and indicated that it would require more effort *($\chi^2 = 23.27$; $df = 1$; $p < 0.0001$)* and time to complete *($\chi^2 = 23.27$; $df = 1$; $p < 0.0001$)*.

These findings support the results from Experiment One. The two assignments comprising Assignment Pair A were constructed so that the high-effort assignment required more time and effort to complete and be more difficult. The mathematics performance data and student perception data from Experiment One and Experiment Two support this effort.

Analysis of Assignment Pair B (High Effort Interspersal vs. Moderate Effort). Table 6 shows for Assignment Pair B, that the mean number of total problems (1x1 plus 3x2) completed for the high-effort interspersal assignment (*M*=6.57; *SD*=2.57) was greater than the moderate-effort assignment (*M*=5.61; *SD*=2.14). This difference was statistically significant *($t = -5.42$; $df = 43$; $p < 0.0001$)*. Table 6 summarizes accuracy data for 3x2 problems across the two assignments in Assignment Pair B. The mean accuracy for the high-effort assignment was 74.79% (*SD*=25.37) and 66.58 (*SD*= 37.46) for the moderate-effort assignment. This difference was not significant *($t=1.42$; $df=43$; $p=0.16$)*. The mean number of 3x2 problems completed was 5.61 (*SD*=2.15) for the moderate effort assignment and 4.57 (*SD*=1.86) for the high-effort interspersal assignment. Analysis showed a significant difference between the number of 3x2 problems completed on the moderate-effort assignment and high-effort interspersal assignment *($t = 5.88$; $df = 43$; $p < 0.0001$).*

Table 7 provides a summary of choice and perception data for Assignment Pair B. Half (22 of 44 students) chose the high-effort interspersal assignment for homework. Chi-square analysis showed no significant differences for homework choice *($\chi^2 = 0$; $df = 1$; $p = 1.00$).* No significant differences were found for time *($\chi^2 = 0.36$; $df = 1$; $p = 0.55$),* effort *($\chi^2 = 0.36$; $df = 1$; $p = 0.55$)* or difficulty *($\chi^2 = 0$; $df = 1$; $p = 1.00$)* rankings.

<u>Across Assignment Pair Analyses.</u>

Mathematics Performance. Assignment Pair B was constructed to determine if interspersing additional brief problems on the high-effort assignment would a) increase problem completion rates on the high effort assignment b) increase the proportion of students choosing the high effort assignment for homework, and c) enhance students' perceptions of the high effort assignments.

Interspersing the brief problems caused an increase in the number of problems completed on the high-effort assignment (3.77 on the high effort to 6.75 on the high effort with interspersed brief problems). ANOVA showed a significant difference among the total number of problems completed across assignments *($F = 13.37$, $df=4$, $p<0.0001$).* Results from Tukey's Post Hoc Analysis (presented in Table 8 with effect sizes for significant differences) revealed a significant difference between the total number of problems completed on the High Effort Assignment in Assignment Pair A and the High Effort Interspersal Assignment (3x2 problems plus brief problems) in Assignment Pair B. No significant differences were found between the Moderate Effort Assignments.

One concern with interspersing additional brief problems is this procedure may reduce opportunities to respond to longer target items. Results showed that interspersing the brief problems did not decrease the number of long target problems completed on the high-effort assignment (M=3.77 on the high effort, Assignment Pair A and M=4.57 on the high effort with interspersed brief problems, Assignment Pair B). Tukey's Post Hoc Analysis showed no significance difference between the 3x2 problems completed on these assignments. An ANOVA was performed to test for differences in accuracy across assignment pairs (Presented in Table 10, Appendix B). Results from the ANOVA revealed no significant differences across Assignment Pairs *(F=0.94, df=3. p=0.42).*

Choice and Perception Analysis. Pearson's Chi Square Analysis (displayed in Table 8) shows a significant shift in choice. Significantly more students chose the high-effort assignment for homework in Assignment Pair B (22 or 50.00%) relative to Assignment Pair A (6 or 13.64%). Additionally, significantly fewer students ranked the high-effort assignment as being more difficult and requiring more time and effort to complete for Assignment Pair B, relative to Assignment Pair A. The results show that interspersing the brief problems caused significantly more students to choose the high-effort assignment for homework and rate the high-effort assignment more favorably for time, effort, and difficulty.

Shifts in choice and perceptions were analyzed by creating 2x2 contingency tables for each of the choice and perception categories and assessing the effect of adding the interspersal problems. Pearson Chi-Square (Q_p) and odds ratios are presented in Table 8. For each category, there is a strong association between the addition of the interspersal problems and selection (every Q_p significant at the $p<0.01$ level). Analysis of the odds ratios reveals students were approximately 6 times (OR=6.33) more likely to choose the high effort assignment for homework when the interspersal problems are added. Also, students were more likely to perceive the high effort assignments as being less difficult (OR=13.67), time consuming (OR=7.60) and effortful (OR=5.28). These data suggest that the interspersing of brief problems influences students to choose the assignments consisting of all high-effort problems.

Regression Model.

To assess the predictive nature of relative problem completion rates and student assignment choice, a logistic regression model was employed. The model supplies the probability of choosing the high effort assignment for obtained RPCRs.

Logistic regression analysis shows a significant main effect for RPCR ($Q_W=7.8534$; $df=1$; $p=0.0051$). The Hosmer and Lemeshow Goodness of Fit test shows the model fits adequately ($Q_{WS}=2.1111$; $df=6$; $p=0.9092$). Relative problem completion rates are plotted against the predicted probabilities from the model in Figure 2.

Discussion

In the current study, sixth grade students were exposed to two assignment pairs. While working on the first assignment pair, students completed significantly more 3x2 multiplication problems on the moderate-effort assignment than on the high-effort assignment. As in Experiment One, these results suggest that the researchers were successful in their attempt to create assignments requiring unequal amounts of effort while maintaining equal numbers of problems on both assignments. On Assignment Pair

A, significantly more students rated the moderate effort assignment as requiring less time and effort to complete and as being less difficult when compared to the high effort assignment. Thus, assignment perception data suggests that students were able to detect the differences across assignments.

Analysis of Assignment Pair A showed significantly more students chose the moderate effort assignment for homework. This finding supports the results of Experiment One (Assignment Set A) and previous research that suggests that when given a choice of two assignments and all other variables are held constant, students will choose the assignment that requires less effort to complete (Cooke et al., 1993; Winterling et al., 1987). However, if a completed discrete task is a reinforcing event, in Assignment Set A students may have chose the moderate effort assignment because it was associated with higher discrete problem completion rates and rates of reinforcement (Skinner, 2002).

In Assignment Pair B, additional interspersed brief problems were added to the high effort assignment. This procedure increased the effort required to complete the high effort assignment and increased discrete task completion rates on the high effort assignment. The increase in effort should cause a decrease in the probability of student choosing the high effort assignment. However, if the discrete task completion hypothesis is accurate, increasing problem completion rates would have the opposite effect and increase the probability of students choosing the high effort assignment. This is what occurred. Furthermore, ratings of time, effort, and difficulty improved significantly for the high effort assignment when additional brief problems were added. The current results support previous research on the discrete task completion hypothesis which suggests that adding and interspersing brief problems can improve students' perceptions of high effort assignments and increase the probability of students choosing to engage in higher effort assignments.

Theoretical Implications, Limitations, and Future Research.

In Assignment Pair A, students may have preferred (chosen) the moderate effort assignment because it required less time and effort to complete than the high effort assignment. However, in Assignment Pair B the only modification was to intersperse *additional* problems to the high effort assignment. While these additional problems may not have caused a large increase in the effort required to complete the high effort assignment, they could not have decreased the effort required to complete the high effort assignment. As in Experiment One, relative effort cannot explain the increase in the proportion of students choosing the high effort assignment in Assignment Pair B. Thus, the current study extends research on the discrete task completion hypothesis by controlling for effort.

Experiment Two replicates and extends Experiment One. Experiment Two established ecological and educational validity through employing participants where the tasks were appropriate (i.e., sixth grade mathematics students). Reducing the effort required to complete assigned work (i.e., Assignment Set A) can enhance students' perceptions of assignment, increase the probability of students choosing to engage in assigned work, and decrease the probability of students engaging in disruptive behaviors (Cooke et al., 1993; Dunlap & Kern, 1996; Winterling et al., 1987). However, reducing assignment demands can also reduce learning (Roberts & Shapiro, 1996; Roberts et al., 1991). Experiment Two demonstrates that student perceptions of assignments can be enhanced and the probability of choosing to engage in higher effort tasks also can be enhanced by interspersing additional brief tasks. This suggests that educators may be able to enhance assignment perceptions and decrease off-task behavior without reducing assignment demands by interspersing additional brief tasks among assignment comprised of discrete tasks.

CHAPTER V

CONCLUSION

Summary of Studies

In Experiment One, college students were exposed to two pairs of mathematics assignments. The first assignment pair consisted of a high effort assignment containing 18 three-digit-by-two digit (3x2) multiplication problems with all digits greater than three and a moderate effort assignment containing nine problems similar to the high effort assignment and nine moderate problems with all digits less than four except the hundreds position. After working on each assignment for equal amounts of time, significantly more students designated the moderate assignment as being less difficult, time consuming and effortful. Significantly more students also chose the moderate effort assignment for homework. Analysis of the problem completion rates showed students completed significantly more problems on the moderate effort assignment relative to the high effort assignment. According to the discrete task completion hypothesis, the resulting student choices could be accounted for through differences in relative problem completion rates (Skinner, 2002). However, differences in student preference could have also been seen due to lower effort problems in the moderate effort assignment (Cooke et al., 1993; Winterling et al., 1987). Assignment Set B was designed to address this question.

In Assignment Set B, the same group of students was presented two more mathematics assignments. The first assignment was identical in design to that of the moderate effort assignment in Assignment Set A. The second assignment contained high effort 3x2 multiplication problems similar to the high effort assignment in the first assignment pair. However, this high effort assignment also contained six one-digit-by-one-digit (1x1) multiplication problems (one interspersed after every third high effort problem). After working on both assignments for equal amounts of time, students were asked to rate the assignments for time, difficulty, and effort and finally, designate a homework choice. Results from this pair of assignments show a shift in choice and perceptions away from the moderate effort assignment. In this assignment pair, significantly more students rated the moderate effort assignment as less difficult. However, no differences were found for ratings on time, and effort, or homework choice. This may have been due to the increase in total amount of problems completed on the high effort assignment (3x2 problems plus 1x1 brief problems) relative to the moderate effort assignment.

In Assignment Pair B, the total number of problems completed on the high effort assignment was significantly greater than the number of problems completed on the moderate assignment. In this case, relative effort could not be the sole reason for the choice outcome. Through the addition of the interspersal problems, the amount of effort was increased on the high effort assignment relative to the moderate effort assignment. Yet choice shifted away from the moderate effort assignment and towards the higher effort assignment. The discrete task completion hypothesis may be able to account for the shift in choice. As previously mentioned, the number of problems completed per-unit-of-time was significantly greater for the high effort assignment relative to the moderate effort assignment. Like manipulating relative rates of reinforcement in other choice studies, problem completion rates affected choice.

Differences in choice and perceptions across assignment pairs were also analyzed. Chi-square analyses revealed a strong relationship between student choice and the addition of the interspersal problems. Analyses showed that choice differed significantly across studies and analysis of the odds ratios revealed students were much more likely to find the high effort assignment less difficult, time consuming, and effortful through addition of the interspersal problems. The odds of students choosing the high effort assignment were significantly greater with the addition of the brief interspersal problems.

In Experiment Two, sixth grade students were presented the same assignment pairs as was used in Experiment One. Results were similar to those found in Experiment One. By presenting developmentally appropriate material to students, ecological and educational validity was established for the procedures and results of Experiment One.

These results suggest that increasing relative problem completion rates through the addition of brief interspersed problems may be an effective procedure for influencing students to choose assignments containing more effortful target problems (i.e., 3x2 multiplication problems). In other studies (e.g. Cooke et al., 1994), student choice was manipulated by decreasing the amount of assignment effort (i.e., shortening assignment length, replacing target tasks with already mastered tasks). In the current study, it was demonstrated that student assignment choice could be manipulated by adding effort, as long as the added effort results in an increase in relative rate of reinforcement. Thus, the interspersal procedure may have applied potential to influence students to complete more effortful assignments.

The Logistic Regression Models and Matching

The problem completion rates and choice data for individual subjects were entered into a logistic regression. As opposed to linear regression, logistic regression allows fitting of nominal data. Since predicting increases in the actual choice variable is unrealistic in this case, the logistic regression model fits predicted probabilities for each instance of the predictor variable (RPCR). In the present cases, the model is: at a given level of relative problem completion rate, what is the probability that a student will choose the high effort assignment? In both experiments, this model fit adequately. Fitting the logistic regression model to interspersal studies may allow for a better assessment of the interspersal procedure and its relation to the matching law.

Notice that, in the presented matching law equations, two measures are required: A measure of relative reinforcement and a measure of relative responding. In previous interspersal studies, a measure of relative reinforcement was obtained for individuals (relative problem completion rates). Relative responding for the individual could not be obtained since choice was a single response. However, responding was assessed through the percentage of students choosing the interspersal assignment. In the end, researchers were left with two numbers: Percentage of students choosing the interspersal assignment and RPCR for group. Thus, the group is treated as if it were a single subject making multiple responses. While matching can be inferred from such studies, multiple groups (studies) are needed to develop predictive validity in this manner. Skinner (2002) demonstrated that treating the data in this manner could be related to the generalized matching equation. However, the current study suggests that meta-analytic procedures may not be necessary.

The logistic regression model allows for relative rates of reinforcement (RPCR) and a type of relative responding (predicted probability of choosing an assignment) for individuals within a single study. Such analysis allows for a direct comparison to the matching law in the following manner. Notice that in Experiment Two (Appendix B, Figure 2), for a RPCR=1 there is approximately a 0.32 probability that a student will choose the high effort assignment, a clear bias for the moderate effort assignment. Sensitivity to reinforcement can also be assessed with the use of this model. For example, in order to increase the probability that a student will choose the high effort assignment to greater than 0.5 (i.e., chance), the relative problem completion rate must be at least 1.5. This analysis allows for more precise description and prediction in terms of matching than previous analyses.

Theoretical and Applied Implications

In the present studies, students were required to complete mathematics assignments where problem effort was manipulated. Results from Assignment Pair A (in both Experiments One and Two) demonstrated that the researchers were successful in their attempt to create assignments of varying effort (i.e., fewer problems completed on the high effort assignment). The high effort assignments were seen as more difficult, time consuming, effortful, and less likely to be chosen for homework than the moderate effort assignments. This supports previous research on student assignment choice and matching law research in relation to effort (e.g., Billington & Skinner, 2002; Cates &

Skinner, 2000). Assignment Set B demonstrated that students could be influenced to choose the high effort assignment by increasing relative rates of reinforcement (i.e., RPCR).

The current experiments have both theoretical and applied implications. Researchers investigating the discrete task completion hypothesis and interspersal procedure have suggested that problem completion is a reinforcing event (Billington & Skinner, 2002; Cates & Skinner, 2000; Logan & Skinner 1998; Skinner, Robinson et al., 1996). The current findings fit with basic research on the nature of reinforcement. Experimental subjects have displayed increased levels of responding in second order schedules (i.e., schedules of brief stimuli presentation) where the stimuli presented may be a light flash or a change in the color of a key light (e.g., Findley & Brady, 1965; Kelleher, 1966; Neuringer & Chung, 1967). Kelleher (1966) demonstrated that pigeons exposed to a second order FR 30 (FI 2min:S) schedule where FR 30 was reinforced with food and S was a 0.7 second key color change from blue to white exhibited higher response rates than when no light change contingency was in place. However, subjects exposed to chain schedules where different stimuli are presented at each interval show lower rates of responding (Ferster & Skinner, 1957). In simple schedules of reinforcement (i.e., interval and ratio schedules), higher rates of reinforcement result in higher rates of responding (Ferster & Skinner, 1957). Results from brief stimuli research show that higher rates of brief stimuli presentation lead to higher rates of responding (e.g., Kelleher, 1966, Staddon & Innis, 1969). Malone (1990) pointed out that a reinforcer need not be a tangible stimulus, but rather a response dependent occurrence.

Results from brief stimuli research as well as research on the discrete task completion hypothesis supports Malone (1990). For example, in the current study, students were more likely to choose assignments containing more response dependent stimuli (problem completions) and the probability of choice increased as a function of RPCR.

Directions for Future Research

Future researchers should explore other avenues of investigation and address limitations of the current study. For example, in the current study, relative problem completion rates were manipulated by adding brief problems. Researchers should look at alternative methods of manipulating problem completion rates (e.g., explicit timing). Methods and procedures that divide larger tasks into smaller, more discrete steps may also prove useful in manipulating problem completion rates. With the exceptions of Meadows (2001) and Teeple (2001), interspersal studies have employed mathematics tasks. More research needs to be done on applying the interspersal technique to other areas (i.e., Reading, Social Studies, Science, etc.).

All interspersal studies have taken place over a short period of time with limited exposure to assignments (i.e., one class period, one assignment choice). Future research should be directed towards repeatedly presenting assignment choices across time (e.g., through the course of a semester) to determine the interspersal procedure's long-term effectiveness. With the exceptions of Billington and Skinner (2002) and Meadows (2001), students were not required to actually complete the assignments before designating a homework choice. Research should also be conducted to investigate whether or not completing the assignments affect assignment choice.

Educators may find research on the interspersal procedure valuable. Teachers may find applying some behavior principles in the classroom both time consuming and difficult. For example, monitoring and delivering individual reinforcement for academic behaviors might prove tedious and require educators to spend more time with some students and neglect working with others. The interspersal procedure may allow educators to enhance rates of reinforcement for academic responding on a class wide basis, which can increase academic responding, enhance skill development, and decrease inappropriate behavior. Additionally, as this study demonstrates, such procedures also may cause students to choose to engage in higher effort assignment that may enhance learning more than lower effort assignments.

REFERENCES

References

Aparicio, C. F. (2001). Overmatching in rats: The barrier choice paradigm. *Journal of the Experimental Analysis of Behavior, 75,* 93-106.

Baum, W. M. (1974). On two types of deviation from the matching law: Bias and undermatching. *Journal of the Experimental Analysis of Behavior, 22,* 231-242.

Belke, T. W. (1998). Qualitatively different reinforcers and parameters of Herrnstein's (1970) response-strength equation. *Animal Learning & Behavior, 26,* 235-242.

Billington, E.J., & Ditommaso, N. M. (2003). Demonstrations and applications of the matching law in education. *Journal of Behavioral Education, 12,* 91-104.

Billington, E. J., & Skinner, C. H. (2002). Getting students to choose to do more work: evidence of the effectiveness of the interspersal procedure. *Journal of Behavioral Education, 11,* 105-116.

Binder, C. (1996). Behavioral fluency: Evolution of a new paradigm. *The Behavior Analyst, 19,* 163-197.

Cates, B. L., & Skinner, C. H. (2000). Getting remedial mathematics students to prefer homework with 20% and 40% more problems: An investigation of the strength of the interspersing procedure. *Psychology in the Schools, 37,* 339-347.

Cates, G. L., Skinner, C. H., Watkins, C. E., Rhymer, K. N., McNeill, B. S., & McCurdy, M. (1999). Effects of interspersing additional brief math problems on student performance and perception of math assignments: Getting student to prefer to do more work. *Journal of Behavioral Education, 9,* 177-193.

Coleman, R. (1970). A conditioning technique applicable to elementary school classrooms. *Journal of Applied Behavior Analysis, 3,* 293-297.

Cooke, N. L., Guzaukas, R., Presley, L. S., & Kerr, K. (1994). Effects of using a ratio of new items to review items during drill and practice: Three experiments. *Education and Treatment of Children, 16,* 213-234.

Davison, M., & McCarthy, D. (1988). *The matching law.* Hillsdale, NJ: Lawrence Erlbaum.

De Villiers, P. (1977). Choice in concurrent schedules and a quantitative formulation of the law of effect. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior.* Englewood Cliffs, NJ: Prentice-Hall.

De Villiers, P. A., & Herrnstein, R. J. (1976). Toward a law of response strength. *Psychological Bulletin, 83,* 1131-1153.

Dunlap, G., DePerzcel, M., Clark, S., Wilson, D., Wright, S., & Gomez, A. (1994). Choice making to promote adaptive behavior for students with emotional and behavioral challenges. *Journal of Applied Behavior Analysis, 27,* 505-518.

Dunlap, G., & Kern, L. (1996). Modifying instructional activities to promote desirable behavior: A conceptual and practical framework. *School Psychology Quarterly, 11,* 297-312.

Ferster, C. B. & Skinner, B. F. (1957). *Schedules of reinforcement.* Englewood Cliffs, N. J.: Prentice Hall, Inc.

Findley, J. D., & Brady, J. V., (1965). Facilitation of large ratio performance by use of conditioned reinforcement. *Journal of the Experimental Analysis of Behavior, 8,* 125-129.

Greenwood, C. R., Delquadri, J., & Hall, R. V. (1984). Opportunity to respond and student academic performance. In W. Herward, T. Heron, D., Hill, & J. Trap-Porter (Eds.), *Behavior analysis in education.* (pp 58-88). Columbus, OH: Charles E. Merrill.

Haring, N. G., & Eaton, M. D. (1978). Systematic instructional technology: An instructional hierarchy. In N. G. Haring, T. C. Lovitt, M. D. Eaton, & C.L. Hansen (Eds.), *The fourth R: Research in the classroom* (pp. 23-40). Columbus, OH: Merrill.

Herrnstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of the Experimental Analysis of Behavior, 4,* 267-272.

Herrnstein, R. J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior, 13,* 243-266.

Herrnstein, R. J. (1974). Formal properties of the matching law. *Journal of the Experimental Analysis of Behavior, 21,* 159-164.

Heyman, G. M., & Monaghan, M. M. (1994). Reinforcer magnitude (sucrose concentration) and the matching law theory of response strength. *Journal of the Experimental Analysis of Behavior, 61,* 505-516.

Kelleher, R. T., (1966). Conditioned reinforcement in second order schedules. *Journal of the Experimental Analysis of Behavior, 9,* 475-485.

Kern, L., Childs, K. E., Dunlap, G., Clarke, S., & Falk, G. D. (1994). Using assessment based curricula revisions to improve the classroom behavior of a student with emotional challenges. *Journal of Applied Behavior Analysis, 27,* 7-19.

Logan, P., & Skinner, C. H. (1998). Improving students' perceptions of a mathematics assignment by increasing problem completion rates: Is problem completion a reinforcing event. *School Psychology Quarterly, 13,* 322-331.

Mace, F. C., McCurdy, B., & Quigley, E. A. (1990). The collateral effect of reward predicted by matching theory. *Journal of Applied Behavior Analysis, 23,* 197-205.

Malone, J. C. (1991). *Theories of Learning: A Historical Approach.* Belmont, CA: Wadsorth Inc.

Martens, B. K., Halperin, S., Rummel, J. E., & Kilpatrick, D. (1990). Matching theory applied to contingent teacher attention. *Behavioral Assessment, 12,* 139-155.

Martens, B. K., & Houk, J. L. (1989). The application of Herrnstein's law of effect to disruptive and on-task behavior of a retarded adolescent girl. *Journal of Applied Behavior Analysis, 51,* 17-27.

Martens, B. K., Lochner, D. G., & Kelly, S. Q. (1992). The effects of variable-interval reinforcement on academic engagement: A demonstration of matching theory. Journal of Applied Behavior Analysis, 25, 143-151.

McCurdy, M., Skinner, C. H., Grantham, K., Watson, T. S., & Hindman, P. M. (2001). Increasing on-task behavior in an elementary student during mathematics seat-work by interspersing additional brief problem. *School Psychology Review, 30,* 23-32.

Myerson, J., & Hale, S. (1984). Practical implications of the matching law. *Journal of Applied Behavior Analysis,* 17, 367-380.

Neef, N. A., Mace, F. C., & Shade, D. (1993). Impulsivity in students with serious emotional disturbance: The interactive effects of reinforcer rate, delay, and quality. *Journal of Applied Behavior Analysis, 26,* 37-52.

Neef, N. A., Shade, D., & Miller, M. S. (1994). Assessing influential dimensions of reinforcers on choice in students with serious emotional disturbance. *Journal of Applied Behavior Analysis, 27,* 575-583.

Neef, N. A., Mace, F. C., Shea, M. C., & Shade, D. (1992). Effects of reinforcer rate and reinforcer quality on time allocation: Extensions of matching theory to educational settings. *Journal of Applied Behavior Analysis, 25,* 691-699.

Neuringer, A. J. & Chung, S. H. (1967). Quasi-reinforcement: Control of responding by a percentage reinforcement schedule. *Journal of the Experimental Analysis of Behavior, 10,* 45-54.

O'Leary, K. D., Becker, W. C., Evans, M. B., & Saudargas, R. A. (1969). A token reinforcement program in a public school: A replication and systematic analysis. *Journal of Applied Behavior Analysis, 2,* 3-13.

Petry, N. M., & Heyman, G. M. (1994). Effects of qualitatively different reinforcers on the parameters of the response-strength equation. *Journal of the Experimental Analysis of Behavior, 61,* 97-106.

Rachlin, H., & Green, L. (1972). Commitment, choice, and self-control. *Journal of the Experimental Analysis of Behavior, 17,* 15-22.

Roberts, M. L., & Shapiro E. S. (1996). Effects of instructional ratios on students' reading performance in a regular education program. *Journal of School Psychology, 34,* 73-91.

Roberts, M. L., Turco, T. L., & Shapiro, E. S. (1991). Differential effects of fixed instructional ratios on students' progress in reading. *Journal of Psychoeducational Assessment, 9,* 308-318.

Silberman, C. (1970). *Crisis in the classroom.* New York: Random House.

Skinner, C. H. (2002). An empirical analysis of interspersal research evidence, implication, and applications of the discrete task completion hypothesis. *Journal of School Psychology, 330,* 1-22.

Skinner, C. H., Fletcher, P. A., & Hennington, C. (1996). Increasing learning rates by increasing student response rates: A summary of research. *School Psychology Quarterly*, *11*, 313-325.

Skinner, C. H., Hall-Johnson, K., Skinner, A.L., Cates, G., Weber, J., & Johns, J. A. (1999). Enhancing perceptions of mathematics assignments by increasing relative problem completion rates through the interspersal technique. *Journal of Behavioral Education, 68,* 43-59.

Skinner, C. H., Robinson, S. L., Johns, G. A., & Belfiore, P. H. (1996). Applying Herrnstein's matching law to influence students' choice to complete difficult academic tasks. *The Journal of Experimental Education, 65,* 5-17.

Skinner, C. H., Wallace, M. A., & Neddenreip, C. E., (2002). Academic remediation: Educational applications of research on assignment preference and choice. *Child and Family Behavior Therapy, 24,* 51-65.

Staddon, J. E. R., & Innis, N. K. (1969). Reinforcement omission on fixed interval schedules. *Journal of the Experimental Analysis of Behavior, 12,* 689-700.

Sumter, C. E., Foster, T. M., & Temple W. (1995). Predicting and scaling hens' preferences for topographically different responses. *Journal of the Experimental Analysis of Behavior, 63,* 151-163.

Thomas, D. R., Becker, W. C., & Armstrong, M. (1968). Production and elimination of disruptive classroom behavior by systematically varying teacher's behavior. *Journal of Applied Behavior Analysis, 1,* 35-45.

Wearden, J. H., & Burgess, I. S. (1982). Matching since Baum (1979). *Journal of the Experimental Analysis of Behavior, 38, 339*-348.

Wildmon, M. E., Skinner, C. H., McCurdy, M., & Sims, S. (1999). Improving secondary students' perception of the "dreaded mathematics word problem assignment" by giving them more word problems. *Psychology in the Schools, 36,* 319-325.

Wildmon, M. E., Skinner, C. H., & McDade, A. (1998). Interspersing additional brief, easy problems to increase assignment preference on mathematics reading problems. *Journal of Behavioral Education, 8,* 337-346.

Winett, R. A. & Winkler, R. C. (1972). Current behavior modification in the classroom: Be still, be quiet, be docile. *Journal of Applied Behavior Analysis, 5,* 499-504.

Winterling, V., Dunlap, G., & O'Neill, R. E. (1987). The influence of task variation on the aberrant behaviors of autistic students. *Education and Treatment of Children, 10,*105-119.

APPENDICES

APPENDIX A

TABLES

Table 1

Problem Completion Rates and Accuracy Levels For Each Assignment For Experiment 1

	Assignment Pair A				Assignment Pair B			
	Moderate-Effort		High-Effort		Moderate-Effort		High-Effort Interspersal	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total 3x2 Problems Completed (a,b)	10.47	2.93	7.37	2.23	10.02	2.63	11.65	2.90
Percent of 3x2 Target Problems Completed Correctly (a,)	77.41	16.59	65.99	7.53	78.47	18.29	73.66	19.15
Total Problems Completed (b)					10.02	2.63	8.35	2.31

a: Denotes statistical significance within Assignment Pair A

b: Denotes statistical significance within Assignment Pair B

Table 2

Analysis of Assignment Ranking and Homework Choice For Experiment 1

	Assignment Pair A		**Assignment Pair B**	
	High- Effort	Moderate-Effort	High-Effort	Moderate-Effort
More time to complete (a)	39 (76.5%)	12 (23.5%)	26 (51.0%)	25 (49.0%)
More difficult to complete (a, b)	37 (72.5%)	14 (27.5%)	16 (32.0%)	34 (68.0%)
More effort to complete (a)	38 (74.5%)	13 (25.5%)	19 (37.3%)	32 (62.8%)
Homework choice (a)	13 (24.6%)	38 (74.51%)	30 (58.8%)	21 (41.2%)

a: Denotes statistical significance within Assignment Pair A

b: Denotes statistical significance within Assignment Pair B

Table 3

Odds Ratios and Pearson Chi-Square for Choice and Selection Data Across Assignments For Experiment 1

Selection and Choice Categories	**Odds Ratios & Confidence Intervals**	**Pearson Chi-Square (Q_p)**
Time	OR=4.67 CI=1.99--10.97	13.26 (p=.0003)
Difficulty	OR=5.22 CI=2.22--12.26	15.25 (p<0.0001)
Effort	OR=3.04 CI=1.28--7.20	6.60 (p=.010)
Homework	OR=3.99 CI=1.71--9.33	10.70 (p=.001)

Table 4

Tukey's Post-Hoc Analysis of Problem Completion Rates Within and Across Assignment Pairs for Experiment 1

Comparison	**Difference Between Means**	**Effect Size**
Moderate Effort A vs. High Effort A**	3.098	1.19
Moderate Effort B vs. High Effort B (3x2 problems only)**	1.615	
Moderate Effort B vs. High Effort B (3x2 problems plus Interspersal Problems)**	1.667	.67
Moderate Effort A vs. Moderate Effort B	0.471	
High Effort A vs. High Effort B (3x2 problems only)	1.012	
High Effort A vs. High Effort B (3x2 problems plus interspersal problems)**	4.275	1.87
High Effort B (3x2 problems only) vs. High Effort B (3x2 problems plus interspersal problems)**	3.262	4.52
High Effort B (3x2 problems only) vs. Moderate Effort A**	2.12	.80
High Effort B (3x2 problems plus interspersal problems) vs. Moderate Effort A**	1.177	.83
High Effort A vs. Moderate Effort B**	2.65	1.09

**Significant Difference at p=0.05 level

Table 5

Tukey's Post-Hoc Analysis of Assignment Accuracy Within and Across Assignments for Experiment 1

Comparison	Difference Between Means	Effect Size
Moderate Effort A vs. High Effort B**	.1141	.50
Moderate Effort B vs. High Effort B	.0509	
Moderate Effort A vs. Moderate Effort B	.0107	
High Effort A vs. High Effort B**	.0739	.32
Moderate Effort A vs. High Effort B	.0402	
High Effort A vs. Moderate Effort B**	.1249	.49

Table 6

Problem Completion Rates and Accuracy Levels For Each Assignment For Experiment 2

	Assignment Set A				Assignment Set B			
	Moderate-Effort		High-Effort		Moderate-Effort		High-Effort Interspersal	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total Problems Completed (a,b)	5.89	2.23	3.77	1.75	5.61	2.15	4.57	1.86
Percent of 3x2 Target Problems Completed Correctly	73.21	21.03	66.01	25.25	74.79	25.37	66.58	37.46
Total 3x2 Problems Completed (b)					5.61	2.14	6.75	2.57

a: Denotes statistical significance within Assignment Pair A

b: Denotes statistical significance within Assignment Pair B

Table 7

Analysis of Assignment Ranking and Homework Choice for Experiment 2

	Assignment Pair A		**Assignment Pair B**	
	High-Effort	Moderate-Effort	High-Effort	Moderate-Effort
More time to complete (a)	38 (86.36%)	6 (13.64%)	20 (45.45%)	24 (54.55%)
More difficult to complete (a)	41 (93.18%)	3 (6.82%)	22 (50.00%)	22 (50.00%)
More effort to complete (a)	38 (86.36%)	6 (13.64%)	24 (54.55%)	20 (45.45%)
Homework choice (a)	6 (13.64%)	38 (86.36%)	22 (50.00%)	22 (50.00%)

a: Denotes statistical significance within Assignment Pair A

b: Denotes statistical significance within Assignment Pair B

Table 8

Odds Ratios and Pearson Chi-Square for Choice and Selection Data Across Assignments For Experiment 2

Selection and Choice Categories	**Odds Ratios & Confidence Intervals**	**Pearson Chi-Square (Q_p)**
Time	OR=7.6000 CI=2.6710--21.6247	16.3862 (p <0.0001)
Difficulty	OR=13.6667 CI=3.6773--50.7923	20.1702 (p <0.0001)
Effort	OR=5.2778 CI=1.8549--15.0172	10.6998 (p=0.0011)
Homework	OR=6.3333 CI=2.2289--17.9955	13.4095 (p=0.0003)

Table 9

Tukey's Post-Hoc Analysis of Problem Completion Rates Within and Across Assignment Pairs for Experiment 2

Comparison	**Difference Between Means**	**Effect Size**
Moderate Effort A vs. High Effort A**	2.12	1.06
Moderate Effort B vs. High Effort B (3x2 problems only)**	1.04	.52
Moderate Effort B vs. High Effort B (3x2 problems plus Interspersal Problems)**	1.14	.48
Moderate Effort A vs. Moderate Effort B	.28	
High Effort A vs. High Effort B (3x2 problems only)	.8	.44
High Effort A vs. High Effort B (3x2 problems plus interspersal problems)**	2.98	1.52
High Effort B (3x2 problems only) vs. High Effort B (3x2 problems plus interspersal problems)**	2.18	1.08
High Effort B (3x2 problems only) vs. Moderate Effort A**	1.32	.64
High Effort B (3x2 problems plus interspersal problems) vs. Moderate Effort A**	.86	.36
High Effort A vs. Moderate Effort B**	1.84	.94

**Significant Difference at p=0.05 level

Table 10

Tukey's Post-Hoc Analysis of Assignment Accuracy Within and Across Assignments for Experiment 2

Comparison	**Difference Between Means**	**Effect Size**
Moderate Effort A vs. High Effort B	4.36	
Moderate Effort B vs. High Effort B	5.98	
Moderate Effort A vs. Moderate Effort B	1.63	
High Effort A vs. High Effort B	2.84	
Moderate Effort A vs. High Effort A	7.20	
High Effort A vs. Moderate Effort B	8.82	

APPENDIX B

FIGURES

Figure 1

Probability plot for Experiment One

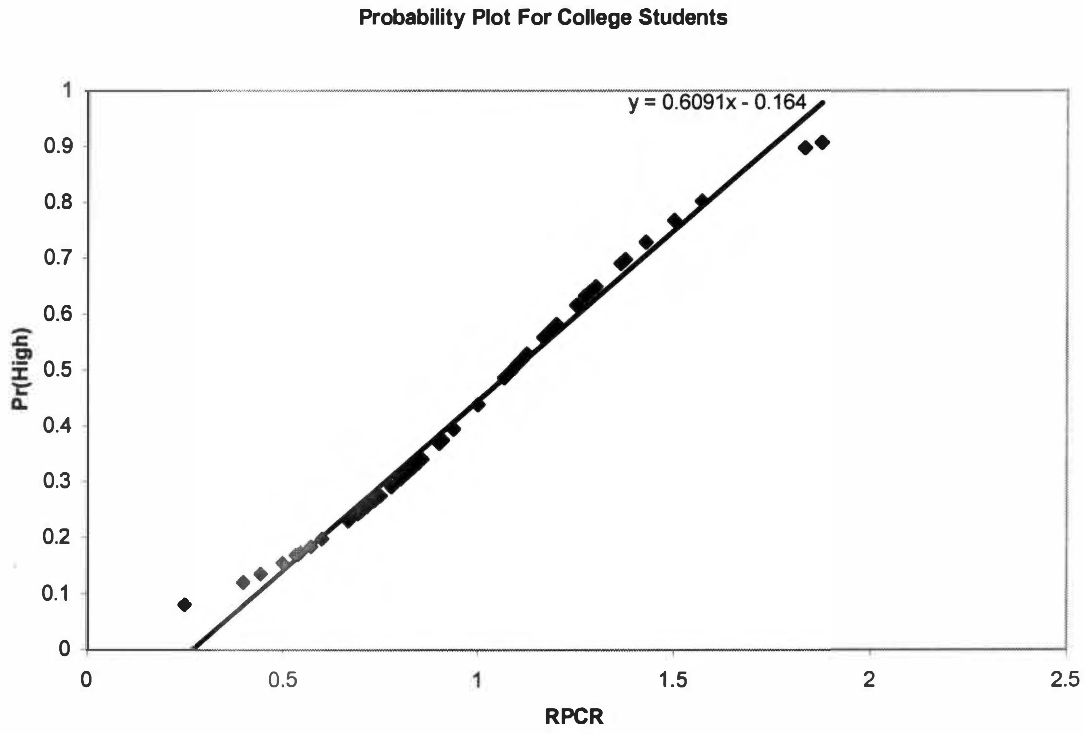
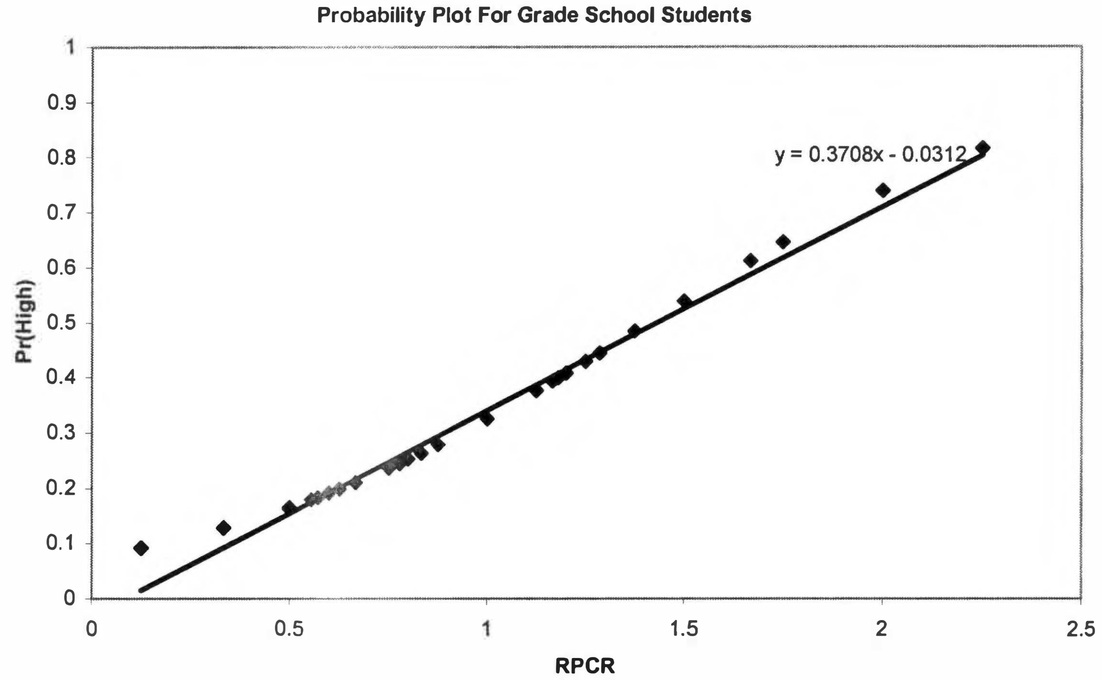


Figure 2

Probability Plot for Experiment Two



APPENDIX C

EXPERIMENTAL MATERIALS

EXPERIMENTAL MATERIALS FOR EXPERIMENT ONE

DESCRIPTION OF RESEARCH AND INFORMED CONSENT STATEMENT

We are conducting a study related to mathematics. Although serving as a subject in this investigation will not benefit you, we hope the results of this investigation will contribute to our theoretical understanding of mathematic curricula. We are asking if you would be willing to volunteer as a subject for this investigation.

As a subject in this study you will first be asked to work on mathematics worksheets. First we will ask you to spend some time working problems on two separate mathematics worksheets. We will also be asking you to answer some questions about the mathematics worksheets. After exposure to each sheet we will give you a choice of a final sheet to complete for homework. The homework assignment should take between 15 and 20 minutes.

Your answers to questions concerning the worksheets and your performance on these mathematics worksheets will be kept strictly confidential. At no point will your name be associated with any of the data collected.

If you choose to participate, you will be given extra credit. (The amount of extra credit is designated by the Psychology Department and subject to approval by your instructor)

INFORMED CONSENT STATEMENT

1. I have been informed of the procedures to be used in this study. I understand that I will be asked to complete some mathematics problems.
2. I understand that there are no known discomforts or risks expected with participation in this study.
3. I understand that there are no direct benefits to be gained from participation in this study, except for extra credit.
4. I understand that I can choose to withdraw from this study at anytime.
5. I understand that after the study is complete I will be informed of the purpose of this study and the results found. If I have any questions regarding this study I can contact Eric Billington (ebillin1@utk.edu / 686-0346).

I, ____ give my consent to participate in this study and I understand that I am completely free to withdraw my consent and discontinue participation at any time for any reason.

Date: ____

DIRECTIONS

There are two sections of this research project. On both sections you will be asked to work two different mathematics assignments. Do not start working until instructed. Work through as many problems as possible without sacrificing accuracy. Work from left to right without skipping any problems. Stop when you reach the bottom of the page or time is called and wait for further instructions. After completing each set of assignments, you will then be asked to answer some questions about the completed assignments.

You may withdraw from this study at anytime.

ASSIGNMENT E

874	533	588
x 56	x 21	x 68

731	987	513	497	823
x 23	x 65	x 32	x 46	x 31

846	713	946	630	545
x 67	x 12	x 94	x 23	x68

803	745	603	768	721
x33	x56	x21	x64	x32

ASSIGNMENT B

478 x 56	895 x 69	885 x 86		
567 x 97	789 x 56	955 x 47	794 x 64	648 x 78
468 x 76	797 x 68	649 x 49	546 x 65	455 x68
598 x 45	547 x 56	693 x 54	786 x46	493 x58

PLEASE COMPLETE THE FOLLOWING INFORMATION

1. SEX ___________ (1= MALE; 2=FEMALE)
2. WHAT IS YOUR AGE? _____________ (NUMBER OF YEARS)
3. WHAT IS YOUR GRADE POINT AVERAGE? __________(2 DECIMALS, e.g. 3.45)
4. WHAT IS YOUR MAJOR AREA OF STUDY? ________________________
5. WHAT IS YOUR ACADEMIC CLASSIFICATION?______

(1=FRESHMAN; 2=SOPHOMORE; 3=JUNIOR; 4=SENIOR; 5=GRADUATE STUDENT)

ABOUT THE WORKSHEETS

PLEASE CIRCLE ONE RESPONSE FOR EACH QUESTION

1. WHICH WORKSHEET IS **MOST DIFFICULT**?

ASSIGNMENT E ASSIGNMENT B

2. WHICH WORKSHEET WOULD REQUIRE THE **MOST EFFORT** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT E ASSIGNMENT B

3. WHICH WORKSHEET WOULD REQUIRE THE **MOST TIME** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT E ASSIGNMENT B

4. YOUR LAST TASK IS TO COMPLETE ONE MORE WORKSHEET AFTER THIS SESSION. YOU MUST COMPLETE THIS ASSIGNMENT FROM BEGINNING TO END. HOWEVER, YOU MAY CHOOSE WHICH WORKSHEET YOU WOULD LIKE TO COMPLETE. WHICH SHEET DO YOU CHOOSE?

ASSIGNMENT E ASSIGNMENT B

ASSIGNMENT I

567	830	748
x 45	x 23	x 59

533	467	613	448	602
x 32	x 68	x 33	x 58	x 13

775	602	857	733
x 65	x 13	x 94	x 21

849	513	845	931	677	730
x 54	x 32	x 58	x23	x74	x32

ASSIGNMENT Z

7   675   748   847
x7   x 54   x 85   x 95

9   445   764   687   6   844   588
x6   x 75   x 68   x 65   x5   x 85   x 54

757   7   688   587   547   8
x 56   x4   x 95   x 94   x 67   x6

589   775   854   9   874   767   548
x 54   x 86   x 58   x5   x 64   x 74   x 75

PLEASE COMPLETE THE FOLLOWING INFORMATION

1. SEX ___________ (1= MALE; 2=FEMALE)
2. WHAT IS YOUR AGE? _____________ (NUMBER OF YEARS)
3. WHAT IS YOUR GRADE POINT AVERAGE? __________(2 DECIMALS, e.g. 3.45)
4. WHAT IS YOUR MAJOR AREA OF STUDY? ________________________
5. WHAT IS YOUR ACADEMIC CLASSIFICATION?______

(1=FRESHMAN; 2=SOPHOMORE; 3=JUNIOR; 4=SENIOR; 5=GRADUATE STUDENT)

ABOUT THE WORKSHEETS

PLEASE CIRCLE ONE RESPONSE

1. WHICH WORKSHEET IS **MOST** DIFFICULT?

   ASSIGNMENT Z   ASSIGNMENT I

2. WHICH WORKSHEET WOULD REQUIRE THE **MOST EFFORT** TO COMPLETE FROM START TO FINISH?

   ASSIGNMENT Z   ASSIGNMENT I

3. WHICH WORKSHEET WOULD REQUIRE THE **MOST TIME** TO COMPLETE FROM START TO FINISH?

   ASSIGNMENT Z   ASSIGNMENT I

4. YOUR LAST TASK IS TO COMPLETE ONE MORE WORKSHEET AFTER THIS SESSION. YOU MUST COMPLETE THIS ASSIGNMENT FROM BEGINNING TO END. HOWEVER, YOU MAY CHOOSE WHICH WORKSHEET YOU WOULD LIKE TO COMPLETE. WHICH SHEET DO YOU CHOOSE?

   ASSIGNMENT Z   ASSIGNMENT I

EXPERIMENTAL MATERIALS FROM EXPERIMENT TWO

DIRECTIONS

There are two sections of this project. On both sections you will be asked to work two different mathematics assignments. Do not start working until instructed. Work through as many problems as possible without sacrificing accuracy. Work from left to right without skipping any problems. Work until time is called or when you reach the bottom of the page. Stop when you reach the bottom of the page or time is called and wait for further instructions. After completing each set of assignments, you will then be asked to answer some questions about the completed assignments as well as choose a new assignment for homework.

ASSIGNMENT E

874 x 56	533 x 21	588 x 68

731 x 23	987 x 65	513 x 32	497 x 46	823 x31
846 x 67	713 x 12	946 x 94	630 x 23	545 x68
803 x33	745 x56	603 x21	768 x64	721 x32

ASSIGNMENT B

478 x 56	895 x 69	885 x 86

567 x 97	789 x 56	955 x 47	794 x 64	648 x 78
468 x 76	797 x 68	649 x 49	546 x 65	455 x68
598 x 45	547 x 56	693 x 54	786 x46	493 x58

PLEASE COMPLETE THE FOLLOWING INFORMATION

SEX ___________ (1= MALE; 2=FEMALE)

WHAT IS YOUR AGE? _____________ (NUMBER OF YEARS)

WHAT IS YOUR GRADE LEVEL? ____________(6^{TH}, 7^{TH}, 8^{TH})

ABOUT THE WORKSHEETS

PLEASE CIRCLE ONE RESPONSE FOR EACH QUESTION

1. WHICH WORKSHEET IS **MOST DIFFICULT**?

ASSIGNMENT E ASSIGNMENT B

2. WHICH WORKSHEET WOULD REQUIRE THE **MOST EFFORT** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT E ASSIGNMENT B

3. WHICH WORKSHEET WOULD REQUIRE THE **MOST TIME** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT E ASSIGNMENT B

4. YOUR LAST TASK IS TO COMPLETE ONE MORE WORKSHEET AFTER THIS SESSION. YOU MUST COMPLETE THIS ASSIGNMENT FROM BEGINNING TO END. HOWEVER, YOU MAY CHOOSE WHICH WORKSHEET YOU WOULD LIKE TO COMPLETE. WHICH SHEET DO YOU CHOOSE?

ASSIGNMENT E ASSIGNMENT B

ASSIGNMENT I

567 x 45	830 x 23	748 x 59

533 x 32	467 x 68	613 x 33	448 x 58	602 x 13

775 x 65	602 x 13	857 x 94	733 x 21

849 x 54	513 x 32	845 x 58	931 x23	677 x74	730 x32

ASSIGNMENT Z

7 x7	675 x 54	748 x 85	847 x 95

9 x6	445 x 75	764 x 68	687 x 65	6 x5	844 x 85	588 x 54

757 x 56	7 x4	688 x 95	587 x 94	547 x 67	8 x6

589 x 54	775 x 86	854 x 58	9 x5	874 x 64	767 x 74	548 x 75

PLEASE COMPLETE THE FOLLOWING INFORMATION

SEX ___________ (1= MALE; 2=FEMALE)

WHAT IS YOUR AGE? _____________ (NUMBER OF YEARS)

WHAT IS YOUR GRADE LEVEL? ____________(6^{TH}, 7^{TH}, 8^{TH})

ABOUT THE WORKSHEETS

PLEASE CIRCLE ONE RESPONSE

1. WHICH WORKSHEET IS **MOST DIFFICULT**?

ASSIGNMENT Z ASSIGNMENT I

2. WHICH WORKSHEET WOULD REQUIRE THE **MOST EFFORT** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT Z ASSIGNMENT I

3. WHICH WORKSHEET WOULD REQUIRE THE **MOST TIME** TO COMPLETE FROM START TO FINISH?

ASSIGNMENT Z ASSIGNMENT I

4. YOUR LAST TASK IS TO COMPLETE ONE MORE WORKSHEET AFTER THIS SESSION. YOU MUST COMPLETE THIS ASSIGNMENT FROM BEGINNING TO END. HOWEVER, YOU MAY CHOOSE WHICH WORKSHEET YOU WOULD LIKE TO COMPLETE. WHICH SHEET DO YOU CHOOSE?

ASSIGNMENT Z ASSIGNMENT I

Student Assent Form

Dear Student,
My name is Eric Billington. I am a graduate student at the University of Tennessee. I am currently working on developing worksheets and assignments that you may like better than typical worksheets and assignments. I am asking if you would be willing to participate in this research.

If you agree to participate, I will ask you to work on some mathematics assignment sheets and ask your opinion about the worksheets. You will be asked to work these assignments during two of your mathematics classes. It will take approximately 15 minutes each class. Participation will not affect your mathematics grade in any way.

This study is voluntary which means that you do not have to participate and can choose which questions you wish to answer. If at any time you choose to quit, just inform your teacher ________, my advisor Dr. Chris Skinner or myself at 974-8403. Furthermore, if you have any questions about the research, feel free to ask your teacher. She can also help you get in touch with Dr. Skinner or me.

If you agree to participate in this research, please check the box below and sign the form in the space provided. Your help is deeply appreciated.

___________ I agree to participate in this research.

Print Name ____

Signature____Date__________
Student

Parental Consent Form

Dear Parent,

My name is Eric Billington. I am a graduate student at the University of Tennessee. I am currently working on developing worksheets that are designed to improve students' attitudes towards schoolwork. I am seeking your consent for your child to participate in this study.

If you agree to allow your child to participate, your child will be asked to complete four mathematics worksheets. These worksheets will be similar to the worksheets regularly given to your child in his/her Mathematics class. Some worksheets will be altered. Specifically, we are going to add some additional problems to the worksheets. Following completion of these worksheets your child will be asked to evaluate these assignments and indicate which they preferred. These worksheets will be administered in two of your child's mathematics classes. Each administration will last approximately 15 minutes.

Participation in this study is voluntary which means they do not have to participate and your child can stop at any time without penalty. Also, this study will have no effect on your child's grade. Only the researchers and the student's teacher will know the identity of the student completing the work or providing information about the assignments. Although results of our research may be shared with others through professional publications or presentation, your child's name will never be revealed.

If you have any questions about this consent or this study, please feel free to contact my faculty advisor, Chris Skinner or myself at 974-8403. If you agree to allow your child to participate in this research, please check the appropriate box and sign the form in the space provided for parental signature or legal guardian. Your help is deeply appreciated.

Sincerely,

Eric J. Billington
University of Tennessee
Phone (865) 974-8403

Check one

________ I DO agree to allow my child to participate in this research.
________I DO NOT agree to allow my child to participate in this research.

Child's Name: ____

Signature: ________________________________Date: _____________
Parent or Legal Guardian

APPENDIX D

INTERNAL REVIEW BOARD
(FORM B)

FORM B
APPLICATION

All applicants are encouraged to read the Form B guidelines. If you have any questions as you develop your Form B, contact your Departmental Review Committee (DRC) or Research Compliance Services of the Office of Research. For PDF version of this form, click here.

FORM B

IRB # ______________________________

Date Received in OR _________________

THE UNIVERSITY OF TENNESSEE

Application for Review of Research Involving Human Subjects

I. IDENTIFICATION OF PROJECT

1. **Principal Investigator Co-Principal Investigator:**
   Eric J. Billington, Dept. of Psychology, (865) 686-0346, ejbillington@att.net
   Faculty Advisor:
   Christopher Skinner, Dept. of Educational Psychology, 974-8403, cskinne1@utk.edu

   Department: Psychology

2. **Project Classification: Dissertation**

3. **Title of Project: Varying problem effort and problem completion rates: An investigation of the interspersal procedure and student assignment choice.**

4. **Starting Date: Upon IRB Approval**

5. **Estimated Completion Date: May, 2004**

    1. **External Funding** *(if any):none*

II. PROJECT OBJECTIVES

Research has demonstrated that students prefer higher effort assignments when brief tasks are interspersed (Billington & Skinner, 2002; Cates & Skinner, 2000; Meadows, 2001). These studies have varied assignment effort by manipulating the number of problems within assignments. The purpose of this study is to manipulate assignment effort by varying problem difficulty and to see if we can influence students to choose more effortful assignments by interspersing brief problems

III. DESCRIPTION AND SOURCE OF RESEARCH PARTICIPANTS

Sixth grade students from Blount County School District (Eagleton Middle School). We require 30 students to complete this study. However, we will include all students who agree to participate. Students initially will be approached through the mathematics teacher. The students' mathematics teacher will distribute parental consent forms during mathematics class.

IV. METHODS AND PROCEDURES

All experimental procedures will take place in the students' regular classroom during the scheduled mathematics period. Students will be presented with two pairs of mathematics assignments for a total of four assignment sheets. The differences between the assignments will be the types of problems presented. Students will work these assignments sets over the course of two days. They will work one assignment set each day for eight minutes (four minutes per assignment sheet). The first assignment pair will contain one assignment composed of 18 three-digit by two-digit multiplication problems (3x2) with all digits within each problem being equal to or greater than four (4). These problems will be designated High Effort problems. An example might be: 578x49. The second assignment will also contain 18 3 x 2 problems. In this assignment, half of the problems will be High Effort problems. The other 3x2 multiplication problem will contain digits of less than four (4) with the exception of the hundreds place (e.g., 532x21). These problems will be designated Moderate Effort problems.

The second assignment pair will be similar in design to the first. One assignment sheet will contain half High Effort problems and half Moderate Effort problems. The second assignment in this pair will contain 18 High Effort problems along with six one-digit-by-one-digit problems (e.g., 4x7) interspersed after every third 3x2 problem.

Problems will not be numbered and will be presented in an unbalanced format (i.e., unequal spacing between problems within rows and unequal number of problems per row) to discourage counting the number of problems on the assignments.

After working on each assignment pair, students will be asked to answer questions about the assignments. Finally, students will be asked to choose an assignment for homework. The in-class and homework assignments will not be part of their class grade.

While consenting students are working on the experimental worksheets, non-consenting students will be working mathematics sheets designated by the mathematics teacher. Hence, all students will be working mathematics assignments at the same time.

V. SPECIFIC RISKS AND PROTECTION MEASURES

The only risk is that students may become bored or frustrated. However, students will be allowed to withdraw from the study at any time with no consequences. Students' names will be removed (cut off) from the demographic sheets and destroyed at the end of the second day in order to protect identities. All materials (informed consent, assent, and experimental packets) will be stored in Claxton Addition Room 538. All identifying materials will be kept in a locked cabinet separate from the experimental packets. This will ensure that student's names and identities are protected and only the investigators will have access to these materials.

VI. BENEFITS

There are no direct benefits to the participants. Results from this study may increase our understanding of how to design assignments that students prefer without watering down the curriculum.

VII. METHODS FOR OBTAINING "INFORMED CONSENT" FROM PARTICIPANTS

Consent forms will be passed out to all students to take home to their parents. These forms will describe the research project and ask for permission for their child to participate in the study.

VIII. QUALIFICATIONS OF THE INVESTIGATOR(S) TO CONDUCT RESEARCH

The primary investigator has three years experience in conducting research on the design of mathematics assignments and two studies (one published, one under review) in this area. The faculty advisor has conducted over 15 related experiments.

IX. FACILITIES AND EQUIPMENT TO BE USED IN THE RESEARCH

All experimental procedures will be performed in the students' regular classroom during their scheduled mathematics period at Eagleton Middle School. Experimental materials (mathematics worksheets, parental consent forms, and student assent forms) will be supplied by the experimenters. Students will supply their own writing instruments.

X. RESPONSIBILITY OF THE PRINCIPAL/CO-PRINCIPAL INVESTIGATOR(S)

The following information must be entered verbatim into this section:

By compliance with the policies established by the Institutional Review Board of The University of Tennessee the principal investigator(s) subscribe to the principles stated in "The Belmont Report" and

standards of professional ethics in all research, development, and related activities involving human subjects under the auspices of The University of Tennessee. The principal investigator(s) further agree that:

1. **Approval will be obtained from the Institutional Review Board prior to instituting any change in this research project.**
2. **Development of any unexpected risks will be immediately reported to Research Compliance Services.**
3. **An annual review and progress report (Form R) will be completed and submitted when requested by the Institutional Review Board.**
4. **Signed informed consent documents will be kept for the duration of the project and for at least three years thereafter at a location approved by the Institutional Review Board.**

XI. SIGNATURES

ALL SIGNATURES MUST BE ORIGINAL. The Principal Investigator should keep the original copy of the Form B and submit a copy with original signatures for review. Type the name of each individual above the appropriate signature line. Add signature lines for all Co-Principal Investigators, collaborating and student investigators, faculty advisor(s), department head of the Principal Investigator, and the Chair of the Departmental Review Committee. The following information should be typed verbatim, with added categories where needed:

Principal Investigator __ERIC BILLINGTON________________________________

Signature ________________________________ Date ________________________

Co-Principal Investigator ______CHRISTOPHER SKINNER______________________

Signature ________________________________ Date ________________________

Student Advisor (if any)______________________________________

Signature_________________________________ **Date** _____________________

XII. DEPARTMENT REVIEW AND APPROVAL

The application described above has been reviewed by the IRB departmental review committee and has been approved. The DRC further recommends that this application be reviewed as:

[X] Expedited Review -- Category(s): _______7___________

OR

[ ] Full IRB Review

Chair, DRC ______ROBERT WILLIAMS_________________________

Signature _______________________________ **Date** _______________

Department Head ___________STEVE MCCALLUM_______________________

Signature_______________________________ **Date** _______________

Protocol sent to Research Compliance Services for final approval on (Date) ______________

Approved:
Research Compliance Services
Office of Research
404 Andy Holt Tower

Signature____ Date
____

Vita

Eric Billington was born in Poplar Bluff, MO on June 23, 1970. He graduated with his B.S. in Psychology from Arkansas State University in August of 1998. In July 2003, he completed the requirements for Doctor of Philosophy degree in Psychology from the University of Tennessee, Knoxville.

He has presented nine empirical studies at regional and national research conferences. He has two first author publications and two manuscripts under review in peer reviewed journals as well as two manuscripts in preparation at the time of his doctoral dissertation defense.